MISSOURI
HAZARD
ANALYSIS

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August 1999

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M E M O R A N D U M

To: ALL STATE-WIDE HAZARD ANALYSIS HOLDERS

From: JERRY B. UHLMANN, DIRECTOR OF SEMA

This revised Missouri State-wide Hazard Analysis is the result of the collective efforts of all the branches of SEMA. This analysis is an assessment of various risks facing the state and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison.

We are pleased to present the FY '99 revisions to the State Hazard Analysis in loose-leaf format to insert in your copy of the plan. Each year, we will be forwarding those annexes that require additional revisions or updates, as they are completed by our staff.

State agencies and local jurisdictions should use this hazard analysis for planning, prioritizing, and resource allocation. The information contained herein should identify capabilities essential to disaster response; for determining the probable effectiveness of allocating resources in emergency situations; and for encouraging the cooperation of various political subdivisions and emergency services in formulating regulations, plans and programs in order to mitigate disasters and minimize loss of life, human suffering and damage to public and private property.

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PURPOSE

As we look forward to the 21st century, we can see that the emergency management community faces new and different threats. Gone are the days when emergency management was only for natural disasters and nuclear preparedness. We now face more technologically and politically based hazards that demand the attention of the emergency management community. These new hazards include a number of threats that have not been adequately dealt with in the past, including hazardous materials releases, civil disorders and terrorism.

This document has been compiled to identify the multiplicity of hazards that exist at varying locations and degrees of magnitude throughout the state and to determine the impact these potential hazards would have on residents, property and the environment. The information contained herein should identify capabilities essential to disaster response; for determining the probable effectiveness of allocating resources in emergency situations; and for encouraging the cooperation of various political subdivision and emergency services in formulating regulations, plans and programs in order to mitigate disasters and minimize loss of life, human suffering and damage to public and private property. In addition, a thorough hazard analysis provides a foundation for educating senior government officials and the public on dangers posed by various hazards.

This Hazard Analysis is an assessment of various risks facing the state and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (i.e., toxicity, demographics, topography, etc.); and should be used in planning and prioritizing allocation of resources by state and local officials.

The hazards presented here are those that have been experienced by or pose a potential threat to Missourians. However, local or isolated problems which constitute a potential disaster should not be overlooked.

The following definitions explain the ratings for each hazard:

Probability--The likelihood or the occurrence of the hazard

Low Little or no chance of happening.

Moderate The probability of occurrence is possible.

High The probability of occurrence is considered sufficiently high as to assume the event will occur.

Severity--The deaths, injuries or damages (property or environmental) that the hazard could create if it occurred

Low Little or minor damages or injuries if event occurred.

Moderate Injuries to personnel and damages to the environment and property can be expected.

High Death and major injuries and major damages will occur.

The following is a list of the hazards covered in the analysis and the overall rating they were given by the state:

Tornadoes
Probability - High
Severity - High

Floods (Major and Flash)
Probability - High
Severity - High

Dam Failures
Probability - Low
Severity - Moderate

Drought
Probability - Moderate
Severity - Moderate

Heat Wave
Probability - Moderate
Severity - Moderate

Earthquakes
Probability - High
Severity - High

Severe Winter Weather/Snow /Ice/Severe Cold
Probability - High (North of Missouri River)
Low (South of Missouri River)
Severity - Moderate (North of Missouri River)
Moderate (South of Missouri River)

Fires (Structural & Urban)
Probability - High
Severity - Moderate

Fires (Wild)
Probability - Moderate
Severity - Low to Moderate

Attack (Nuclear/Conventional /Chemical/Biological)
Probability - Low
Severity - High

Terrorism/Sabotage/Civil Disorder
Probability - Low
Severity - Low to High

Utilities (Interruptions and System Failures)
Probability - High
Severity - Low

Mass Transportation Accidents
Probability - Moderate
Severity - Moderate

Hazardous Materials (Fixed Faculty Accidents)
Probability - Moderate
Severity - Moderate

Hazardous Materials (Transportation Accidents)
Probability - High
Severity - Moderate

Nuclear Power Plants (Emergencies/ Accidents)
Probability - Moderate
Severity - Moderate

Public Health Emergencies (Influenza Pandemic)
Probability - High
Severity - Moderate to High

INTRODUCTION

Missouri's location, in the mid-section of the United States, makes it prone to several kinds of natural hazards. Missouri has a continental climate, i.e., the weather is changeable with large variations in temperature and precipitation.

Missouri serves as the major crossroad of the nation for transportation and has an abundant share of industrial, agricultural and recreational facilities. Thus, the possibility of man-made disasters such as hazardous materials releases, fixed nuclear facility incidents and other human action emergencies does exist.

Missouri can be divided into the four topographically distinct regions: glaciated plains in the north; plains or prairie in the west; lowlands in the extreme southeast; and the Missouri Ozarks in between.

The plains section, both glaciated and unglaciated, encompasses nearly all the area north of the Missouri River and a large area south of the river in the western part of the state. The topography varies from rolling hills in the east to hills in the west that average about450 feet above sea level. There are numerous wide, flat valleys cut by the river.

The Ozarks, which comprise about half of the state, is a rugged area of sharp ridges and deep narrow valleys. Elevations range from about 1,000 to more than 1,600 feet above sea level.

The southeastern lowlands cover about 3,000 square miles with elevations from 230 to 300 feet above sea level. Much of the region is excellent farmland, drained by an extensive system of drainage ditches.

Situated along two of the continent's greatest rivers, the Missouri and the Mississippi Rivers, the potential for great floods is ever present. While six large flood control dams have been built on the mainstream of the Missouri River, they have not eliminated the flood threat.

Warm and cool air masses collide along sharply divided "fronts," accompanied by violent thunderstorms having intense rains, strong winds, hail and occasional tornadoes. These frontal storm systems can pass across the state at any time of the year, but are most frequent during the spring months (March, April and May).

There is a well worn saying in Missouri about the weather, "If you don't like today's weather, stick around 'cause it'll change." This saying embodies two important truths about Missouri's weather; (1) the state is subject to weather extremes, (2) extreme weather changes can occur rather quickly.

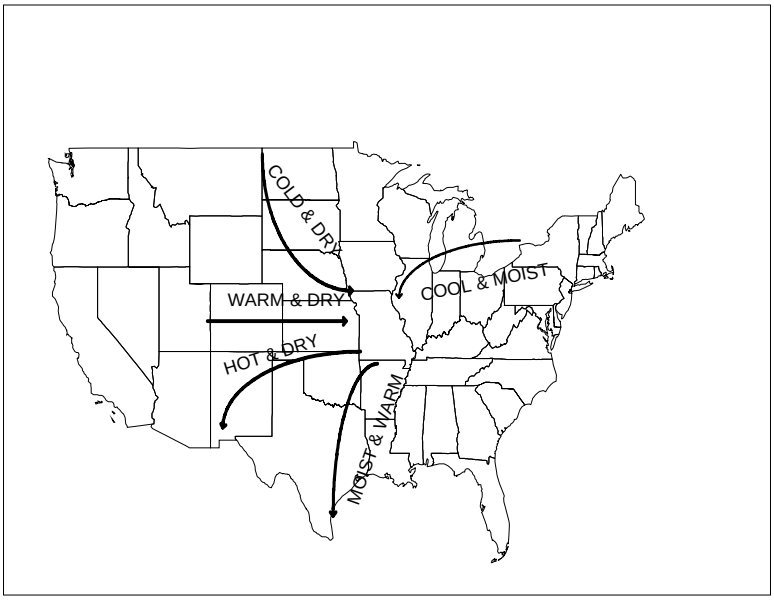
Most of the natural disasters that occur in Missouri (with the exception of earthquakes, land subsidences, and possibly dam failures) are a result of a weather extreme, or an extreme weather change. Since Missouri is situated in the center of the United States, it is subject to many different influences that determine weather patterns.

According to Dr. Grant Darkow [1], Department of Atmospheric Science at the University of Missouri-Columbia, there are specific recognizable weather patterns that are responsible for Missouri's

weather, especially those that "tend to produce extremes in precipitation resulting in unusually wet or drought conditions, and extremes in temperature, either abnormally warm or cold." Darkow explains,

> "The character of air over Missouri on any particular day or series of days is dominated by the source regions from which it comes. Missouri's mid-continental location makes it subject to air flows from a variety of source regions with markedly different properties.
>
> The state is close enough to the Gulf of Mexico that warm air with high humidities can flow into the state from a southerly direction at almost any time of the year. This warm, moist air is the principal source of spring, summer and fall precipitation and, occasionally, in winter as well.
>
> In contrast, air arriving over Missouri from semi-arid to arid regions to the southwest is warm or hot and usually dry. Air that has moved from west to east over the Rocky Mountains arrive warm and dry, having lost most of its low-level moisture as it climbed the west side of the mountains.
>
> Abnormally cold air in the winter and cold summer air with only very small moisture content arrives over Missouri from the northwest or north, whereas air entering Missouri from the northeast will tend to be cool and moist." (Figure 1.)

Figure 1. Source regions and atmospheric characteristics for air arriving in Missouri.



Darkow goes on to explain,

> "Normally, the flow from one of the principal source regions will last for two or three days before switching to a different direction and source region. These transitions typically are accompanied by a frontal passage during which the change in wind direction, temperature, and moisture content, or any combination, is concentrated.

---

[1] Grant L. Darkow, Missouri Weather Patterns and Their Impact on Agriculture, University Extension, University of Missouri-Columbia.

In some instances, however, a particular flow pattern may be very persistent or dominant for a period of weeks or even months. These periods can lead to wet, dry, hot, or cold spells, and the extremes associated with these periods. These periods are characterized by particular upper air flow patterns and associated surface weather patterns." (See Figures 3a, 3b, 4a, 4b, 5a, 5b)

Figure 3a. Upper Air Pattern (Precipitation Producing).

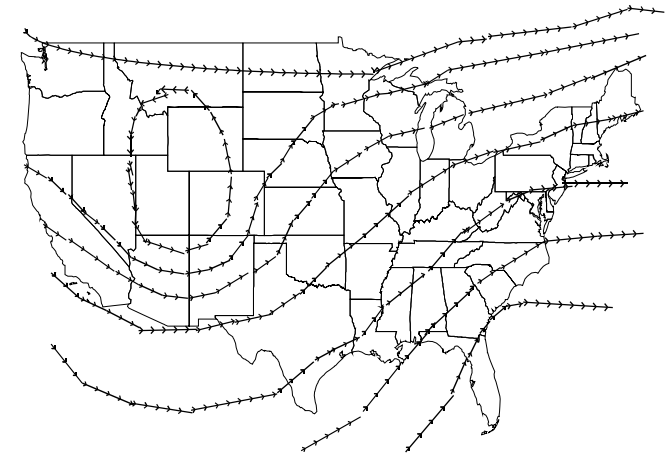


Figure 3b. Surface (Precipitation Producing.

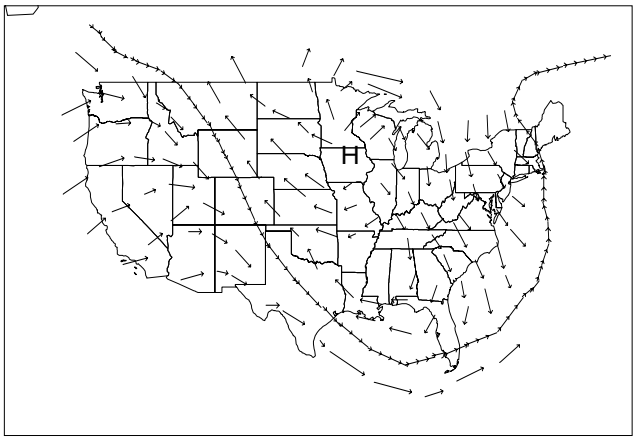


Figure 4a. Upper air pattern (dry to drought producing).

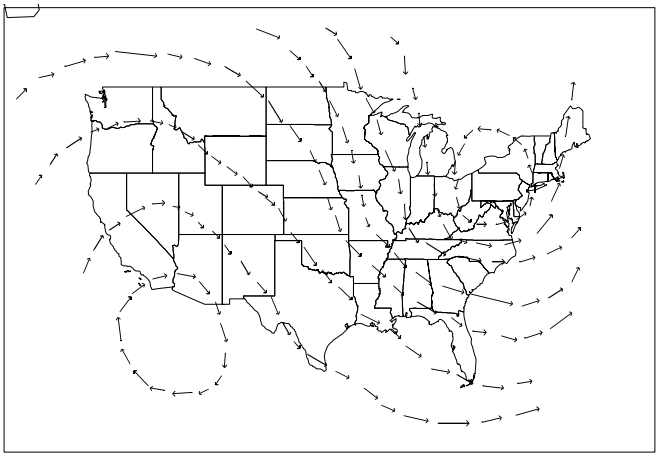


Figure 4b. Surface pattern (dry to drought producing).

Figure 5a. Upper Air Pattern (cold-dry case).

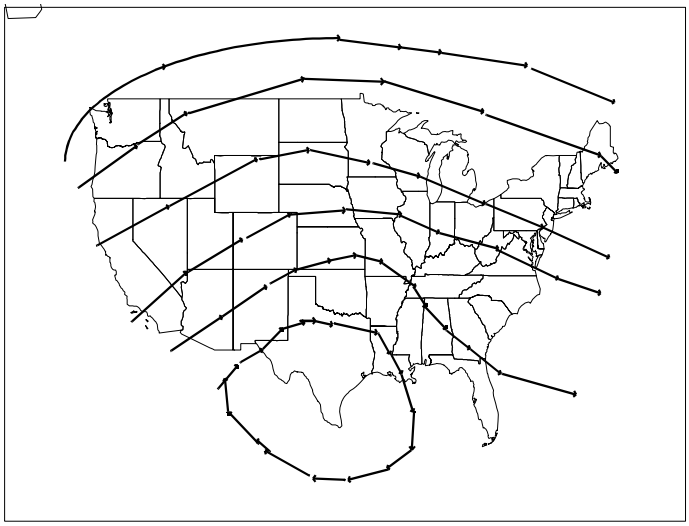
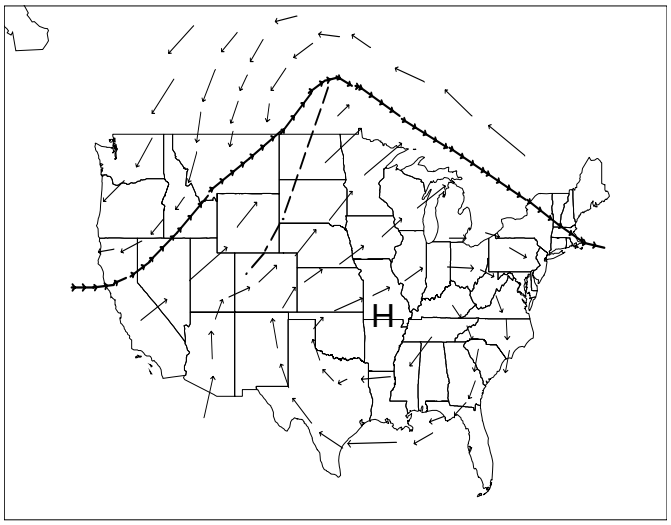


Figure 5b. Surface pattern (cold-dry case).



"The persistence of these weather patterns, and the possible resulting condition is the subject of several of the natural disasters discussed in this study. Specifically, floods, droughts, fires, heat waves, severe cold and winter storms can be the result of the persistence of one of these weather patterns, whereas tornadoes can represent the outgrowth of rapid shifts in weather patterns. Knowing these patterns may assist in alerting disaster planners and the general public to the possibility of a developing emergency situation."

The Missouri State Emergency Operations Plan (1995) considers the following types of disasters:

NATURAL DISASTERS: Natural disasters can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short window in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expansive, with some warning time to allow the public time to prepare, such as flooding. The following is a list of natural disasters prevalent to Missouri:

- Tornadoes
- Floods
- Water (Interruptions and Drought)
- Earthquakes/Land Subsidence
- Wild Fires (Forest, Prairie, and Grasslands)
- Winter Storms and Severe Cold
- Heat Wave
- Severe Weather

MAN-MADE DISASTERS: Each year there is an increase in man-made incidents which can be just as devastating as natural disasters. The following is a list of man-made disasters that could affect the State of Missouri:

- Structural and Urban Fires
- Utilities (Interruptions and Failures)

- Fixed Facility and Transportation Nuclear Hazards
- Hazardous Materials; Other Environmental Issues
- Mass Transportation Incident
- Nuclear Attack
- Conventional Attack
- Biological and Chemical Attack
- Terrorism
- Sabotage
- Civil Disorder
- Dam Failure
- Public Health Emergencies

This hazard analysis will deal only with these indicated disasters.

In the U.S., 95 percent of all Presidentially-declared disasters are weather or flood related events. In Missouri, 100 percent of the Presidentially-declared disasters since 1975 are also weather or flood related. Table 1 is a summary of Presidentially-declared disaster for Missouri since 1975. Under Type of Assistance, IA denotes Individual Assistance, while PA denotes Public Assistance.

Table 1. Presidential Declarations for Missouri Since 1975

Declaration Date	Incident Type	# of Counties Designated	Type of Assistance By County
May 3, 1975	Tornadoes, High Winds and Hail	4	IA & PA - 4
July 21, 1976	Severe Storms and Flooding	4	IA & PA - 4
Sept. 24, 1976	Drought	94	PA Only - 94
May 7, 1977	Tornadoes, Flooding	7	IA & PA - 7
Sept. 14, 1977	Severe Storms and Flooding	6	IA & PA - 6
March 12, 1979	Ice Jam, Flooding	2	PA Only - 2
April 21, 1979	Tornadoes, Torrential Rains & Flooding	17	IA Only - 1 IA & PA - 16
May 15, 1980	Severe Storms & Tornadoes	1	IA Only - 1
Aug. 26, 1982	Severe Storms & Flooding	3	IA Only - 1 IA & PA - 2

Declaration Date	Incident Type	# of Counties Designated	Type of Assistance By County
Dec. 10, 1982	Severe Storms & Flooding	17	IA Only -18 PA Only - 1 IA & PA - 5
June 21, 1984	Severe Storms & Flooding	11	IA Only - 1 PA Only - 8 IA & PA - 2
Oct. 14, 1986	Severe Storms & Flooding	30	IA Only - 7 PA Only - 15 IA & PA - 8
May 24, 1990	Severe Storms & Flooding	10	IA Only - 2 IA & PA - 8
May 11, 1993	Severe Storms & Flooding	8	IA Only - 8
July 9, 1993	Severe Storms & Flooding	102	IA Only - 14 IA & PA - 88 (Cities) IA & PA - 3
Dec. 1, 1993	Severe Storms, Tornadoes and Flooding	24	IA Only - 10 IA and PA - 14
April 21, 1994	Severe Storms, Tornadoes and Flooding	18	IA Only - 18
June 2, 1995	Severe Storms, Tornadoes and Flooding	61	IA Only - 18 (Cities) IA Only - 1 IA & PA - 43
Oct. 19, 1998*	Severe Storms and Flash Flooding	2	IA Only - 2 (Cities) IA Only - 1
Oct. 14, 1998	Severe Storms and Flash Flooding	19	IA and PA - 5 PA Only - 14
April 20, 1999	Storms and Flooding	6	IA Only

*** Declaration was for incident in July 1998, and approved Oct. 19, 1998 following State appeal.**

Table 2 shows the total eligible amount for Public Assistance disaster declarations in Missouri from 1990-1995. Public Assistance provides state/federal assistance for uninsured losses to public property and infrastructure within those counties included in the disaster declaration.

Table 2. Public Assistance for Missouri Flood Disasters, 1990-1995

Date	DR#	Number of Applicants	Damage Survey Reports	Total Amount Eligible
Spring 1990	0867	72	2,023	$9,461,555
Summer 1993	0995	901	14,479*	$140,859,657*
Fall 1993	1006	38	565*	$3,281,066*
Spring 1995	1054	329	2,275*	$17,404,027*
Fall 1998	1253	104	869	$11,217,783*
	TOTALS	1,444	20,211*	$182,224,088*

*Figures as of June, 1999

Table 3 shows the total amount of Individual Assistance for IA declared disasters in Missouri from 1990-1995. Individual Assistance provides state/federal assistance to individuals and families for uninsured losses within those counties included in the disaster declaration.

Table 3. Individual Assistance for Missouri Flood Disaster, 1990-1995

Date	DR #	Individual Assistance	Total Number of Applicants
Spring 1990	867	$4,000,000	700
Spring 1993	989	$1,591,241	447
Summer 1993	995	$65,690,976	15,478
Nov. 1993	1006	$2,796,562	673
Spring 1994	1023	$2,116,639	779
Spring 1995	1054	$4,297,039	1,868
July 1998	1256	$1,093,865	1,763*

Date	DR #	Individual Assistance	Total Number of Applicants
Fall 1998	1253	$1,251,679	1,623*
Spring 1999	1270	$559,725	203*
	TOTALS	$83,397,726	23,534

* Figures as of June, 1999

Table 4 shows the total projected Federal expenditures through September 30, 1994 for four major disasters.

Table 4. Federal Disaster Expenditures

Disaster Incidents	Declaration Date	Projected Federal Expenditures (in Millions of Dollars)
Hurricane Andrew	August 1992	3937.1
Hurricane Iniki	September 1992	554.2
Midwest Floods	Summer 1993	6011.7
Northridge Earthquake	January 1994	3714.6*

* Note that this column represents expenditures through September 30, 1994 and some, especially in the case of Northridge Earthquake, will increase.

FOREWORD

Lately, disasters appear to be occurring on a more frequent basis than during previous years. Federal, State and local emergency managers need to prepare for, respond to and recover from the increasing frequency and scope of disasters. While recent major disasters are memorable, the increased rate of occurrence is remarkable. Disasters in the 1980's were nearly twice as frequent as disasters in the 1970's. From1993-1995 alone, Missouri has experienced five flood disasters, including one which exceeded the once in every 500 years flood levels. According to some weather forecasters, the country has entered a period of extremely destructive weather patterns.

The foundation in emergency preparedness is planning how to handle disasters. The art of perfecting how to respond to disasters is enhanced by the ability to bring together the key players for periodic exercises which stimulate actual disasters.

This Hazard Analysis should be used in planning and allocation prioritizing by state and local officials. Local officials can utilize this document to develop their own localized hazard analysis.

POPULATION

Missouri has a surface land area of 68,995 square miles with a population of 5,117,073 (1990 census).

Missouri ranks fifteenth among the fifty states in population; eighteenth in land area and twenty-seventh in population density. There are 960 incorporated cities, towns, and villages in the state.

In 1830, the first year in which Missouri was enumerated as a state, it had a population of 140,455. The 1970 census showed 4,677,623 inhabitants; and in the 1980 census, there were 4,917,444 residents; in 1990, the census indicated another increase of people to 5,117,073.

The population center of the United States continues to inch westward and is currently located a quarter mile west of the City of DeSoto, Missouri.

Missouri Population 5,117,073

Area Square Miles 68,995

Population Equivalent per square mile 67.79

Number of incorporated cities, towns and villages 960

Number of Counties 114

Urban Population 70%

Metropolitan Population . . . . . 64% of total urban population

Cities with a population of 50,000 or more 5

Counties with population of ½ million or over
(St. Louis and Jackson) 2

Counties with population of 100,000 to 200,000
(Clay, Greene and Jefferson) 3

Counties with population of 50,000 to 100,000
(Boone, Buchanan, Franklin, Pulaski and St. Charles) 5

Counties with a population of 25,000 to 50,000 25

Counties with a population of 15,000 to 25,000 25

Counties with a population of 10,000 to 15,000 23

Counties with a population of 1 to 10,000 32

Ten of the 114 counties or 8.77 percent represent over 74 percent of the total population; two of these ten (St. Louis and Jackson counties), contain 34 percent of the state's total population.

Approximately two million employees earn their living in Missouri. Each year more than 30,000 new high school graduates enter the state's labor market.

ANNEX A

TORNADOES AND SEVERE THUNDERSTORMS (DOWNBURSTS, LIGHTNING, HAIL, HEAVY RAINS, WIND)

I. TYPE OF HAZARD

Tornadoes and Severe Thunderstorms (Downbursts, Lightning, Hail, Heavy Rains, Wind).

II. DESCRIPTION OF HAZARD

Tornadoes are cyclical windstorms often associated with the midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains. For the purpose of this analysis, tornadoes are considered in one category. Other severe weather activities, noted above, are referenced separately in the Synopsis section of this annex (see Part VI).

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles an hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside. Although tornadoes have been documented in all 50 states, most of them occur in the central United States. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun "moves" north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level, and are commonly formed when gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air, and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is “anchored” to a cloud, usually a cumulonimbus, that is also in contact with the earth's surface. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been

known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening, but have been known to occur at any hour of the day or night.

Tornadoes are classified according to the F- Scale (developed by Dr.Theodore Fujita, a renowned severe storm researcher). The F- Scale attempts to rank tornadoes according to wind speed based on the damage caused (Table A-1).

TABLE A-1

FUJITA TORNADO DAMAGE SCALE

SCALE	WIND SPEED**(MPH)	TYPICAL DAMAGE
F0	<73	Light damage: Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; signboards damaged.
F1	73-112	Moderate damage: Surface peeled off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage: Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage: Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forests uprooted; heavy cars lifted off the ground and thrown some distance.
F4	207-260	Devastating damage: Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown, and large missiles generated.
F5	261-318	Incredible damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles propelled through the air more than 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Notes:

Developed in 1971 by T. Theodore Fujita of the University of Chicago.

**Do not use F-scale wind speeds literally. These wind speed numbers are actually estimates and have never been scientifically verified. Different wind speeds may cause similar damage from place to place – even from building to building. Without a thorough engineering analysis of tornado damage in any event, the actual wind speeds needed to cause that damage are unknown.

The National Weather Service, 2003

TABLE A-2

MISSOURI TORNADOES BY F-SCALE, 1950-1996

SCALE	PERCENTAGE
F0	47
F1	24
F2	16
F3	12
F4	1
F5	0

III. HISTORICAL STATISTICS

Historically, the State of Missouri has experienced numerous tornadoes of varied intensities. On May 27, 1896, between the hours of 2 and 8 p.m., a series of 18 tornadoes known as the "St. Louis, Missouri, Outbreak" struck Missouri and Illinois. These tornadoes resulted in 306 deaths and $15 million in damages (see Figure A-1).

The National Weather Service reported that 1400 tornadoes had occurred in Missouri from 1950 to 2002, with 160 deaths and over $900 million in damages. This averages 26 tornadoes per year and 3 deaths per year.

The worst tornado in U. S. history, in terms of deaths and destruction, occurred in Missouri on March 18, 1925, between 1 and 6 p.m. (see Figure A-2). The great "tri-state" tornado originated in Reynolds County. It proceeded east-northeast through the southern quarter of Illinois and into Indiana, covering 219 miles. It caused over $18 million in damage, affected six states, and killed 689 persons.

The City of Poplar Bluff, Missouri, was almost wiped out by a tornado on May 9, 1927. This tornado cost 92 lives and $2 million in damages. The same day, two severe tornadoes struck St. Louis, Missouri. The first tornado moved across the entire city from the western city limits to the Mississippi River through the Lafayette Park area, killing 306 people in Missouri and Illinois and causing almost $13 million in damages. The second tornado started in the southwestern part of the city and proceeded through the Tower Grove

Figure A-1
St. Louis, Missouri, Tornado Outbreak

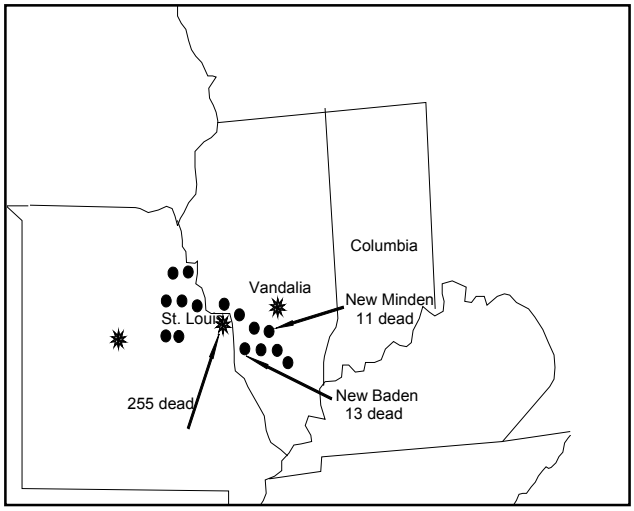
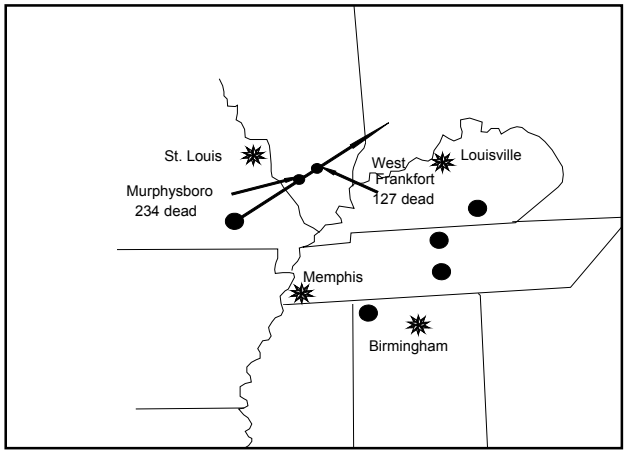


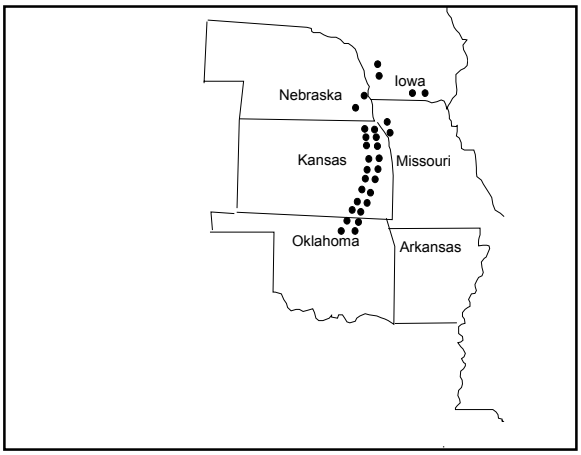
Figure A-2
The Great Tri-State Tornado of 1925



and Vanderventer areas, then on to Granite City, Illinois. Seventy-nine people were killed, and about $23 million in damages resulted from this storm.

During the afternoon and evening of April 3, and the early morning of April 4, 1974, a "super outbreak" of 148 tornadoes across 13 states killed more than 300 people, injured more than 6,000 and caused $600 million in damages (see Figure 3).

Figure A-3
The Tornado Super Outbreak in 1974



On the afternoon of April 26, and the early morning of April 27, 1991, an outbreak of 54 tornadoes covering six states, including Missouri, resulted in 21 deaths, 308 injuries, and damages exceeding $277 million. There were two deaths in vehicles and 15 deaths in and near mobile homes.

On July 4, 1995, at approximately 5:40 p.m., a tornado struck the Randolph County community of Moberly. The initial touchdown of the storm was south of town. The storm then moved through the eastern half of the community. The tornado uplifted approximately 7 miles northeast of Moberly. At least 15 people were injured, 25 businesses damaged, along with the courthouse, and some 300 families affected. This resulted in a Small Business Administration disaster declaration for low interest loans. The tornado was characterized by the National Weather Service as a class F3 tornado.

On May 4, 2003, many tornadoes erupted from the southwest portion of Missouri. These tornadoes produced three major damage tracks, killing one person in Liberal, three people in Stockton, and two people in Carl Junction. Tornado statistics for 2003 have yet to be added to the National Weather Service database.

Figure A-4

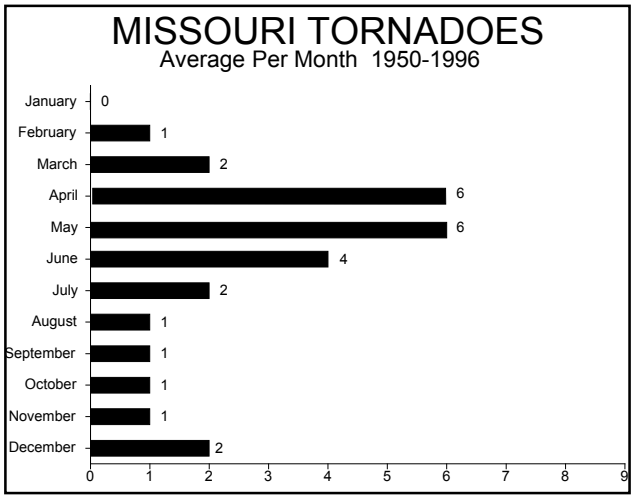


Figure A-4 shows that tornadoes in Missouri occur most frequently between April and June, with April and May usually producing the most tornadoes. However, tornadoes can occur any time of the year, such as the storms that struck in St. Charles and Barry Counties in November 1988.

For a listing of Missouri tornadoes that resulted in federal disaster declarations since 1975, see Table A-3 in Section VII.

IV. MEASURE OF PROBABILITY AND SEVERITY

The United States has 10 times more tornadoes than any other nation in the world. Missouri averages 26 tornadoes per year, and has recorded 1,400 tornadoes from 1950 through 2002. Missourians have a high probability that tornadoes will continue to affect their lives. The natural phenomena that create tornadoes will continue to occur beyond our ability to control them.

The enormous power and destructive capability of tornadoes are beyond mankind's capabilities to control. The potential severity of effects from tornadoes will continue to be high. We will continue to experience deaths, injuries, and property damages from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

V. IMPACT OF THE HAZARD

Every tornado is a potential killer, and many are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. Sticks, glass, roofing material, and lawn furniture all become deadly missiles when driven by tornado winds. In 1975, a Mississippi tornado carried a home freezer for more than a mile. Once, a tornado in Broken Bow, Oklahoma, carried a motel sign 30 miles and dropped it in Arkansas. Tornadoes do their destructive work through the combined action of their strong rotary winds and the impact of windblown debris. In the most simple case, the force of the tornado's winds push the windward wall of a building inward. The roof is lifted up, and the other walls fall outward. Until recently, this damage pattern led to the incorrect belief that the structure had exploded as a result of the atmospheric pressure drop associated with the tornado.

VI. SYNOPSIS

Tornadoes are usually associated with severe thunderstorms, which by themselves, possess destructive potential. Such storms most often occur in the spring and summer, during the afternoon and evenings, but can occur at any time. In addition to tornadoes, other hazards associated with thunderstorms include the following:

- Damaging winds
- Lightning and resulting fires
- Hail
- Heavy rains causing flash flooding.

The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour.

In May 1996, a Memorial Day weekend storm identified by the National Weather Service as a microburst caused more than $10 million in damage to homes in Lee’s Summit, Missouri. The storm destroyed at least 13 homes and damaged more than 100 others in several Lee’s Summit subdivisions. The city also incurred a substantial cost for debris removal and cleanup activities resulting from this devastating storm.

Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour. Large hail can reach the size of grapefruit. Hail causes several hundred millions of dollars in damage annually to property and crops across the nation. In addition, lightning kills 75 to 100 people each year. During the period of 1992 through 1996, seven people died in Missouri as a result of lightning strikes, compared to two deaths from tornadoes during the same period. The thunderstorms associated with tornado development also contribute to the number one weather killer–flash floods. Flash flooding causes 146 deaths annually throughout the nation. During the period from 1992 through 2002, flooding and flash floods claimed the lives of 60 Missourians. Thunderstorms and severe winds claimed five lives over this same period.

VII. MAPS OR OTHER ATTACHMENTS

The following charts and maps depict additional Missouri tornado information, generally for the period between 1950 and 2000:

- Disaster Declarations For Missouri Tornadoes Since 1975: Table A-3
- Missouri Tornadoes by County, Top Twenty-Five, 1950-2003: Figure A-5
- Missouri Tornadoes by County, 1950-2003: Figure A-6
- Missouri Tornado Deaths by County, Top Ten, 1950-2003: Figure A-7
- Missouri Tornado Deaths by County, 1950-2003: Figure A-8
- Missouri Tornado Statistics, 1950-2002: Table A-4.
- Spring 2003 Tornados: Table A-9.

TABLE A-3

DISASTER DECLARATIONS FOR MISSOURI TORNADOES SINCE 1975

DATE	INCIDENT TYPE	COUNTIES DECLARED	TYPE OF ASSISTANCE
May 3, 1975	Tornadoes, High Winds, Hail	Caldwell, Newton, Macon, Shelby	PA & IA
May 7, 1977	Tornadoes, Flooding	Carroll, Clay, Lafayette, Ray, Cass, Jackson, Pettis	PA & IA
May 15, 1980	Severe Storms, Tornadoes	Pettis	IA Only
May 1986	Tornadoes	Scott, Mississippi, Cape Girardeau, Perry	SBA Loans
November 1988	Tornadoes	St. Charles, Barry	SBA Loans
July 1995	Tornadoes	Randolph, (City of Moberly)	SBA Loans
May 6, 2003	Tornadoes, Severe Storms, Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Sainte Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA
May 6, 2003	Tornadoes, Severe Storms, Flooding	Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA

Notes:

IA Individual Assistance
PA Public Assistance
SBA Small Business Administration

FIGURE A-5

MISSOURI TORNADOES BY COUNTY
TOP TWENTY-FIVE – 1950-2003

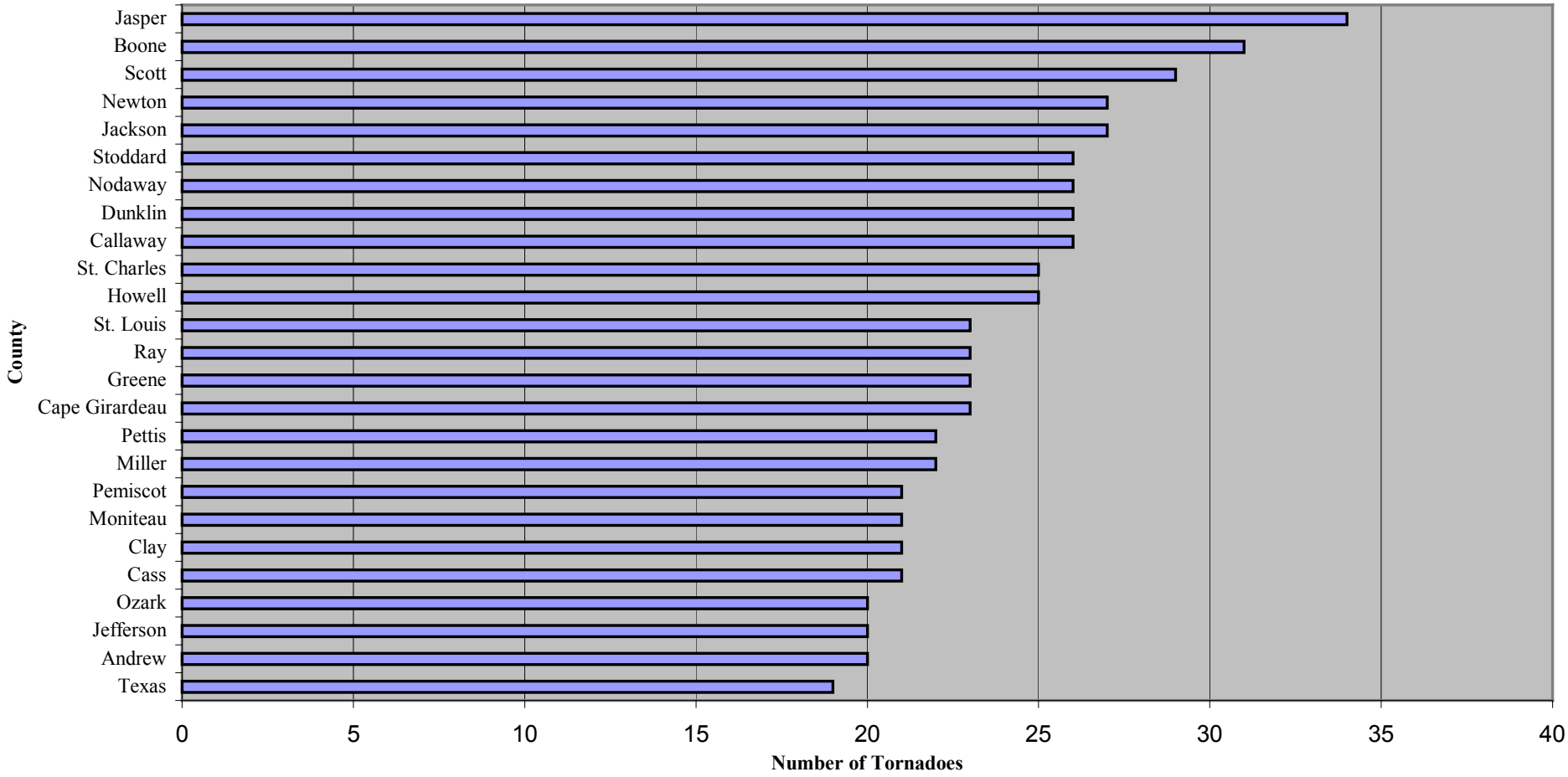


FIGURE A-6

MISSOURI TORNADOES BY COUNTY (1950-2003)

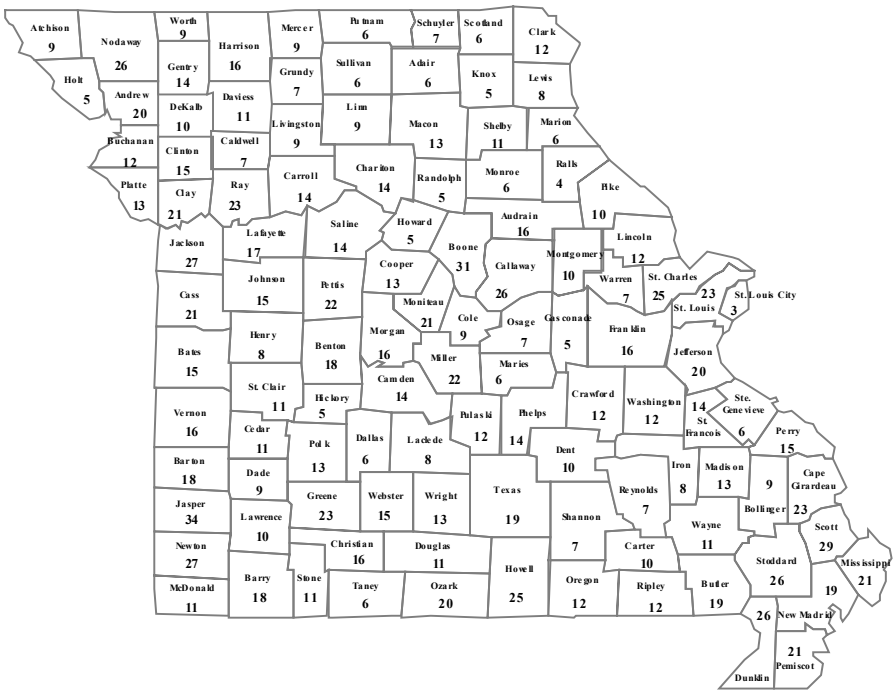


FIGURE A-7

MISSOURI TORNADO DEATHS BY COUNTY
TOP TEN 1950-2003

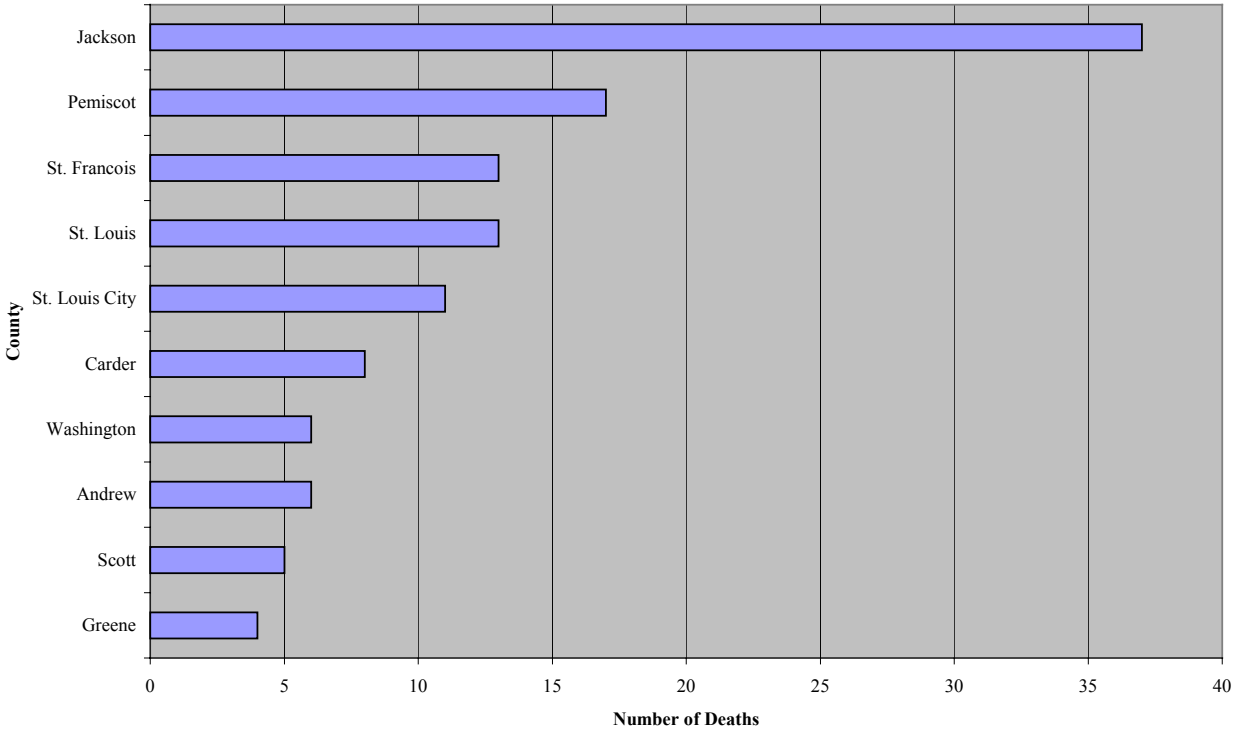


FIGURE A-8

MISSOURI TORNADO DEATHS BY COUNTY (1950-2003)

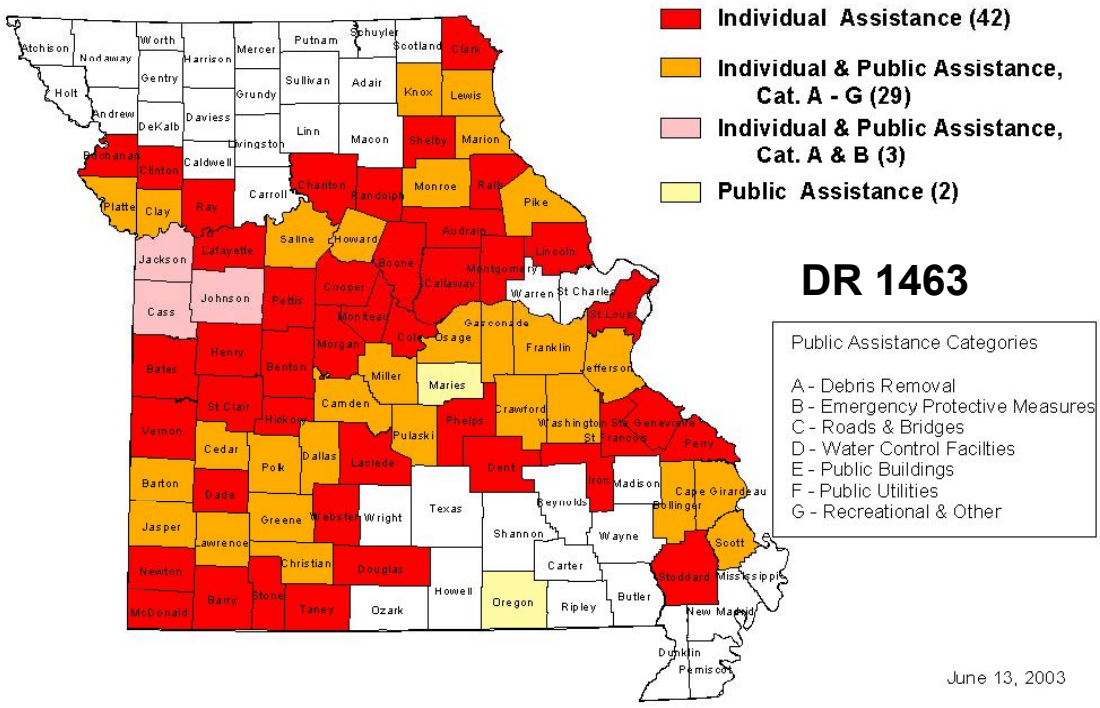
TABLE A-4

MISSOURI TORNADO STATISTICS
1950 – 2002

Total Number of Tornadoes	1,400
Total Number of Deaths	160
Total Number of Injuries	2,383
Yearly Average of Tornadoes	26
Yearly Average of Deaths	3
Yearly Average of Injuries	45
Tornado Deaths 1916 - 2002	620

FIGURE A-9

SPRING 2003 TORNADOS



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RIVERINE FLOODING

(INCLUDES FLASH FLOODS)

I. TYPE OF HAZARD

Riverine Flooding

II. DESCRIPTION OF HAZARD

Floods are the number one weather-related killer in the United States. Between 1993 and 1999, Missouri recorded more than 75 deaths attributed to flooding. A flood is partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt or ice. There are several types of riverine floods–including headwater, backwater, interior drainage, and flash flooding, which is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks and streams, and can also occur as a result of dams being breached or overtopped. Because flash floods can develop in just a matter of hours, most flood related deaths result from this type of flooding event.

The areas adjacent to rivers and stream banks that serve to carry excess flood water during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat areas adjoining rivers and streams. The term base flood, or 100 year flood is the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year, based upon historical records. Floodplains are a vital part of a larger entity called a basin--defined as all the land drained by a river and its branches.

The land that forms the State of Missouri is contained within either the Mississippi, Missouri, Arkansas, or White River Basins. The Mississippi River Basin drains the eastern part of the state; the Missouri River Basin drains most of the northern and central part of the state; the White River Basin drains the south central part of the state; while, the Arkansas River Basin drains the southwest part of the state. The Missouri River Basin drains over half the state as the river moves west to east across the state. When the Missouri River joins the Mississippi at St. Louis, it becomes part of the Mississippi River Basin--the largest basin in terms of volume of water drained on the North American continent.

The fact that most of the land that comprises the State of Missouri is part of the Mississippi-Missouri River drainage basin means that a significant portion of the land area of the state lies in floodplains. St. Charles County, for example, has 43% of the land that comprises the county in floodplains. In terms of agricultural land in Missouri, 34% of Missouri's cropland lies in a floodplain. This leaves much of the Missouri population and economic resources extremely vulnerable to flooding.

In some cases, however, flooding may not necessarily be directly attributable to a river, stream or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall and/or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations - areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns.

III. HISTORICAL STATISTICS

Missouri has a long and active history in terms of extensive flooding over the past century. Scores of river communities, such as those along the Mississippi and Missouri rivers, have become quite skilled and experienced in their flood fighting efforts due to rather frequent instances of severe flooding in recent years. Flooding along Missouri's major rivers is generally characterized as slow moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, these flood disasters extract a heavy toll in terms of human suffering and extensive losses to public and private property. By contrast, flash flood events, which are characterized by a rapid water rise with little warning time, have caused a higher number of deaths and major property damage in many areas of Missouri in recent years.

Ranking among the state's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the Flood of 1951, which caused an estimated $400 million dollars in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of $40 million. The unseasonably heavy rainfall produced severe headwater flooding along many of the areas tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood which spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned in Missouri, as well as in Michigan, Illinois, Kansas and Oklahoma, with all these states declared as federal disaster areas. Significant flooding next occurred in the state in the spring of 1990, particularly along the Missouri River in western, central, and portions of eastern Missouri. Record-level, repetitive flooding occurred from1993-1995, and flash flooding ravaged several areas of the state in July and October of 1998. In the spring of 2000 and spring1999, flash flooding and severe storms again battered portions of the State.

NOTE: Counties designated as Disaster Areas in the 2000,'99, '98 and the'93-'95 Floods are identified, by Disaster Declaration, in maps shown in Section VII of this annex.

SPRING 2000 and '99 FLOODS

For two consecutive spring seasons, Missouri experienced devastating flash flooding which forced hundreds of people from their homes and caused millions in property damage to both homes and businesses. Although the flash flooding in both events was confined to fewer areas, the type of devastation was equal or greater than some of Missouri's worst river flooding events. On May 6-7, 2000, a slow-moving storm unleashed 15 inches of rain in Franklin and Jefferson Counties in less than 24 hours. The city of Union in Franklin County was among the hardest hit due to extreme flooding from Flat Creek. In all, a total of 10 counties were included in Presidential Disaster Declaration MO DR 1328, issued on May 12, 2000. Three counties were declared eligible for Public Assistance and Individual Assistance, and seven others were declared for Individual Assistance.

On April 3rd, 1999, a heavy rain storm in Southeast Missouri caused severe flash flooding in Madison County, including the communities of Fredericktown and Marquand. One death (due to electrocution) was attributed to that flood event when 7 to 10 inches of rain fell in a two-hour period,

causing the St. Francois River to crest at twice the height of flood stage. More than 400 homes were adversely affected, with nearly half receiving significant water damage within the living spaces. Seven businesses were damaged, with five determined to be destroyed.

On April 20, 1999, a Presidential Disaster Declaration for Individual Assistance(MO-DR 1270) was approved for Madison County, and five additional counties (Andrew, Cole, Osage, Iron and Macon) were later approved by FEMA as add-ons to that declaration as a result of subsequent tornadoes and storms on April 8th. More than 30 Missouri counties were also designated as eligible for disaster relief for agricultural losses suffered from the April storms.

FLOODS OF '98

Severe flash flooding in the summer and fall of 1998 took a heavy toll in terms of lives lost and extensive property damage in several areas of the state. In all, at least 17 people died as a result of the two flood events. Almost all of the casualties occurred when people attempted to drive their vehicles through rushing water, overturned their vehicle into floodwaters, or were trapped and swept off a flooded bridge. Both flood incidents ultimately resulted in Presidential Disaster Declarations to provide state-federal assistance in the counties declared.

In the summer event, a storm front on July 10th 1998 caused severe rains and sheet flooding that damaged more than 1,100 residences in St. Louis City and County. Another storm system beginning on July 25th caused flash flood damage to several hundred homes in the Kansas City area, and more than $4 million in damages to numerous county roads, bridges, culverts, and low water crossings in 13 South-Central Missouri counties. Five flood-related deaths were attributed to that storm, including a family of four in Cole County (Osage City) and one death in Cooper County. A Presidential Disaster Declaration (MO-DR 1256) was issued for St. Louis City, St. Louis County, and Jackson County to cover sewer/storm water back-up and other flood related damages to homes and some businesses in the declared areas.

The storms in July and several weeks earlier caused widespread damage to crops in many counties in northern, central, south central and southeast Missouri. More than 70 counties were included in a U.S. Department of Agriculture disaster declaration requested by the State to help farmers recover from their storm-related losses caused by hail, sheet flooding, and heavy winds.

On October 4, 1998, a severe storm system moved into Kansas and Missouri, dumping between 4-11 inches of rain from Kansas City across rural Missouri. Twelve people in the Kansas City metropolitan area drowned in the flash flood incident, including 7 people who died when their vehicles were swept off the Prospect Street bridge over flood-swollen Brush Creek. The Kansas City area alone received almost 8 inches of rain that day, and some locations were hit by a five inch deluge in one hour, according to the National Weather Service. At least three small dams were overtopped the evening of October 4, or the morning of October 5. They were located in Lee's Summit (Jackson County), near Kearney in Clay County, and Silver Lake near Raymore (Cass County), according to the Missouri Department of Natural Resources, Dam and Reservoir Safety program.

As some rural counties continued to complete repairs on roads and infrastructure damaged by the July flash floods, the punishing October rains destroyed much of the repair work and caused new

damages to county infrastructure over a broader area (totaling over $11 million). A Presidential Disaster Declaration was issued on October 14, 1998 for 19 Missouri counties. Five counties in western Missouri were declared eligible for both Individual Assistance and Public Assistance, while another 14 counties were declared for Public Assistance only.

FLOODS OF '93-95

The Floods of 1993-1995 represent Missouri's worst repetitive flood events. Within this time frame, there were five Presidential Disaster Declarations, including four in just one12-month period. This extends from May 6, 1993 when the first declaration was issued by President Clinton, to April 17, 1994, when the fourth declaration was approved. Flooding in the Spring of '95 resulted in a fifth disaster declaration, issued on June 2, 1995. The ravages of the '93-'95 floods left a legacy of destruction, human suffering and property damage of unprecedented terms in Missouri history. The fact that Missouri would need several years to recover from the ravages of these repetitive flood disasters was undisputed. In 1993 alone, a total of 112 of Missouri's 114 counties were included in at least one or more of the declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the state were not included in any of the '93 declarations.

SPRING '93 FLOODS

The origins of the Great Flood of '93 began with an extended period of wet weather starting 9-10 months prior to the onset of major flooding. Soils throughout the upper midwest became saturated by excessive rain in July, September, and especially November of 1992. This set the stage for rapid runoff and record flooding following another period of excessive rain in January through July of 1993. Precipitation in Missouri during that time was 150 to 200 percent above normal. Additionally, Kansas, Nebraska, and Iowa experienced significant rainfall during this same period.

Heavy spring rains which soaked the grounds in eastern Missouri during April and May 1993 caused extensive flooding in St. Charles and Lincoln counties. Six other eastern Missouri counties along the Mississippi River (Marion, Pike, Ste. Genevieve, St. Louis, Ralls, and Jefferson) were also adversely affected. These eight counties were included in the state's first Presidential Declaration in 1993 for Individual Assistance as a result of spring flooding.

SUMMER '93 FLOOD

The rains continued into July and by mid-summer, prolonged rains produced catastrophic flooding along both the Mississippi and Missouri rivers, and their tributaries. A total of 102 counties and 3 cities were federally declared disaster areas for either Individual Assistance and/or Public Assistance. More than 30,000 Missourians evacuated their homes during the summer flooding and at least 21 deaths were attributed to that flood event. With these evacuations, it was estimated that more than 15,000 - 17,000 Missourians were unable to return to their homes for some time due to the flood damage. During the course of the summer flooding, 22 major river bridge closings, 250 routes, and 950 individual flood sites caused road closures in 112 counties. More than 280 million sandbags were used during the summer flooding alone.

The '93 summer flood represents the first time in which the Federal Response Plan was ever activated for a disaster in Missouri. There were 35 Disaster Application Centers (DACs) opened across the state, including two mobile DACs to serve rural populations.

The average rainfall in the month of July was 9.48 inches. Northwest Missouri counties reporting more than 20 inches of rain in July included Holt, Nodaway, Andrew, Buchanan, Worth, Gentry, Mercer, Grundy, Sullivan, and Putnam. The 29 inches of rain that fell in Worth County during July were seven times the long term average and 18 inches greater than the previous record in 1958. (See table in Section VII for record water stages.)

FALL '93 FLASH FLOODS

Severe storms from November 13-19 combined with saturated soils to trigger flash flooding in much of the southeast and eastern areas of the state, and a portion of central Missouri. This resulted in a third Presidential Disaster Declaration for flooding in '93. There were 10 Missouri counties declared eligible for Individual Assistance, and 14 counties were declared for Individual Assistance and Public Assistance. During the November flooding, more than 12,000 people were evacuated and an additional 20 people died.

SPRING '94 FLOODS

Missouri's saturated soil conditions were likened to "a loaded gun with a hair trigger" as spring weather arrived in 1994. Severe weather, rains and early spring flash flooding, compounded by the water logged soil, caused 30 rivers and creeks in every Missouri county to rise between April 9-14. Evacuations were ordered in Lincoln, Reynolds, Jefferson and St. Charles counties. Another 11 Missourians lost their lives as a result of the flood event, which led to the state's fourth Presidential Disaster Declaration in a 12-month period. Ultimately, 17 counties and the City of St. Louis were included in that declaration for Individual Assistance.

SPRING ‘95 FLOOD

The Flood of ‘95 was the second largest flood of record in many areas of Missouri and the third largest flood in others. Severe weather and flooding conditions were widespread over the State throughout much of May. As Missouri River levels rose in the western part of the State, communities downstream began preparations for flooding in their areas. The combination of the Illinois, Ohio and Missouri River flooding caused the Mississippi to flood as well. By May 17, more than 45 Missouri counties suffered from road closures and flood conditions. A 12" rain caused sheet flooding in St. Louis, and citizens in Hazelwood and Maryland Heights were evacuated. On June 2, 1995, President Clinton issued a Disaster Declaration for Public Assistance, which initially included 12 counties. The declaration was later amended on June 12, 1995 to include Individual Assistance. Ultimately, 61 Missouri counties were included under MO-DR 1054, with 43 counties eligible for Public Assistance and Individual Assistance, and 18 counties and one city declared for Individual Assistance only. A total of five deaths were directly attributed to the flooding. Three additional people died from drowning while trying to swim across flooded waters. On July 7, 1995, the U.S. Department of Agriculture issued a disaster declaration for 107 Missouri counties, triggering crop loans for farmers hurt by the prolonged rains and flooding.

Although the ‘95 Flood was very severe in many places, there were some 2,000 fewer families living in the floodplain as a result of Missouri’s hazard mitigation activities under the Community Buyout Program. Begun in the aftermath of the Summer ‘93 Flood, the voluntary program is designed to acquire residential properties in the floodplain and move residents out of harm’s way, using a mix of federal funds. No one could predict Missouri would have the opportunity to test the Buyout’s effectiveness as quickly as it did when the Spring ‘95 Flood struck. Removing these repetitive loss properties from the floodplain saved millions in disaster assistance and emergency protective measures statewide. Likewise, claims for flood insurance and applications for disaster assistance, such as with the Small Business Administration or the Individual and Family Grant Program, were minimized.

IV. MEASURE OF PROBABILITY AND SEVERITY

In terms of overall damage, Missouri's most severe single hazard is flooding. While the state averages some 25 tornadoes each year, damage is generally confined to small areas with few fatalities, if any. By contrast, flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. Prior to the Great Floods of '93, Missouri received federal disaster declarations due to flooding in the spring of 1990: October 1986; June 1984; December 1982; August 1982 (Jackson County); April 1979; September 1977; July 1976: June 1974; and for extensive flooding in April 1973 and again in November 1973. The only other hazard resulting in federal declarations was for tornadoes in 1975 at Neosho, in 1977 at Sedalia and Pleasant Hill, and in 1980 at Sedalia.

Missouri's vulnerability to flooding is greatly increased because it is subject to flooding from two principal sources: the Missouri River Basin and the upper Mississippi River Basin. Over one-third of the annual monetary losses due to flooding in the Missouri River Basin occurs within this state.

Flash flooding could occur virtually anywhere in the state where there is an abundance of rainfall in a very short time span - as witnessed with the November '93 flood disaster, and Floods of ‘98 and ‘99. The backing up of tributary stream flow creates flooding problems along the Mississippi River, especially in the southern area of the state where the land tends to be very flat and at low elevations. Even though many flood control projects have been implemented which directly aid the state in flood prevention, the state is still flood prone due to its geography and location.

The National Weather Service has three response levels for alerting the public as to the danger of floods:

RESPONSE LEVEL	ACTIVITY
Flood Watch	Flash flooding or flooding is possible within the designated area.
Flood Warning	Flash flooding or flooding has been reported or is imminent--take the necessary precautions at once.

Flood Advisory	Flooding of small streams, streets and low-lying areas, such as railroad underpasses and urban storm drains, is occurring.

The threat of flooding is a more natural occurrence in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water, too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains which generate flash flooding along these storm fronts. However, as demonstrated by the disaster declarations in December 1982 and the Great Summer Flood of '93, severe flooding can occur in Missouri at any time of the year. **Based on this information the State rates the probability and severity of floods as high.**

V. IMPACT OF THE HAZARD

The Federal Emergency Management Agency estimates that more than 216,000 households are within designated floodplains in Missouri. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from rapidly rising creeks and tributaries, storm water runoff, etc. Nationwide, most flood deaths are from flash floods, and nearly half of these type of fatalities are auto related, according to the National Weather Service.

Of the 49 deaths recorded during the Floods of '93, 35 fatalities (or 71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles. (See flood-related mortality charts in Section VII.

Missouri flood disasters have inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/ public property, and agriculture. Total losses during the '93 flood disasters were estimated at approximately $3 billion. In addition, agricultural losses were estimated at $1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the '93 rains. The Department of Agriculture estimated that 445,000 acres of Missouri River bottomland was destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up river flooding took their toll. Of the 1,456 public and private levees in the state, some 840 were damaged.

Almost every Missourian was at some time affected by the floods through inundation of roadways, airports, drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that $6.2 million was disbursed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994.

The floods of 1993-94 pointed out the painful fact that too many Missourians were living in the floodplain. To rebuild in the floodplain, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structure above the base flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than $30 million in federal dollars was committed to moving Missourians voluntarily out of the floodplain through the acquisition of primary

residential property. It is estimated that state taxpayers will save more than $200 million in future flood disaster claims.

VI. SYNOPSIS

Flood events are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities as well. Flood waters themselves often interact with the presence of hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers which may break loose or puncture as a result of flood activity. Such events occurred during the '93 Flood when some 11,000 St. Louis residents residing near flood-threatened propane tanks were evacuated on July 30th. Evacuations were also ordered on July 31 when bulk propane tanks were flooded by the River Des Peres in St. Louis County. Federal and state agencies retrieved more than 247 large storage tanks, 1,178 small tanks, 3,470 large drums (over 15-gallon), and 5,731 small drums which had been swept away by the floods.

Public health concerns which develop as a result of flooding include the need for disease and injury surveillance, community sanitation to evaluate flood affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns.)

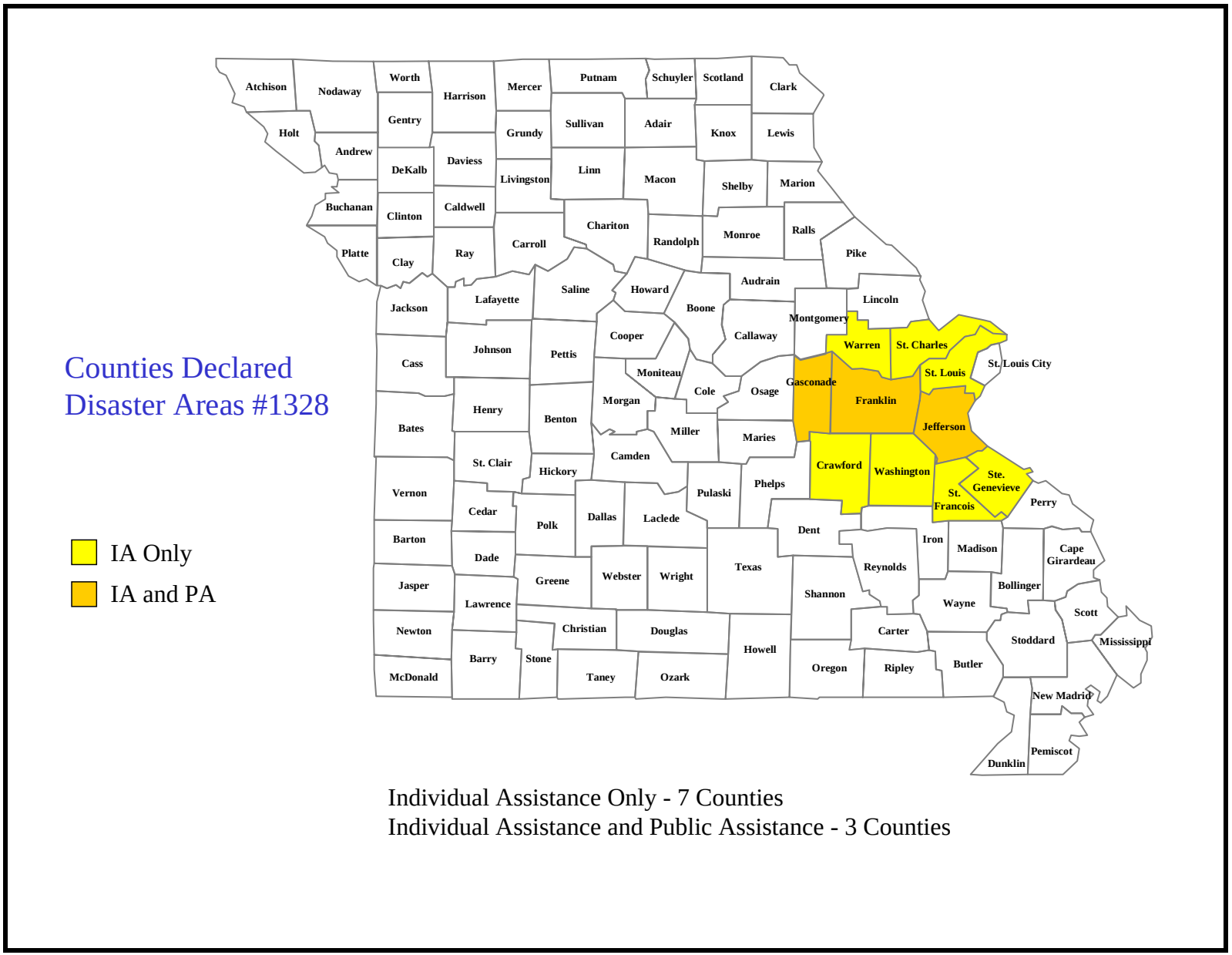
VII. MAPS OR OTHER ATTACHMENTS

River Basin and Floodplain Maps are on file at the State Emergency Management Agency.

The following maps and tables depict additional Missouri flood information, generally from 1993-1999.

Figure 1

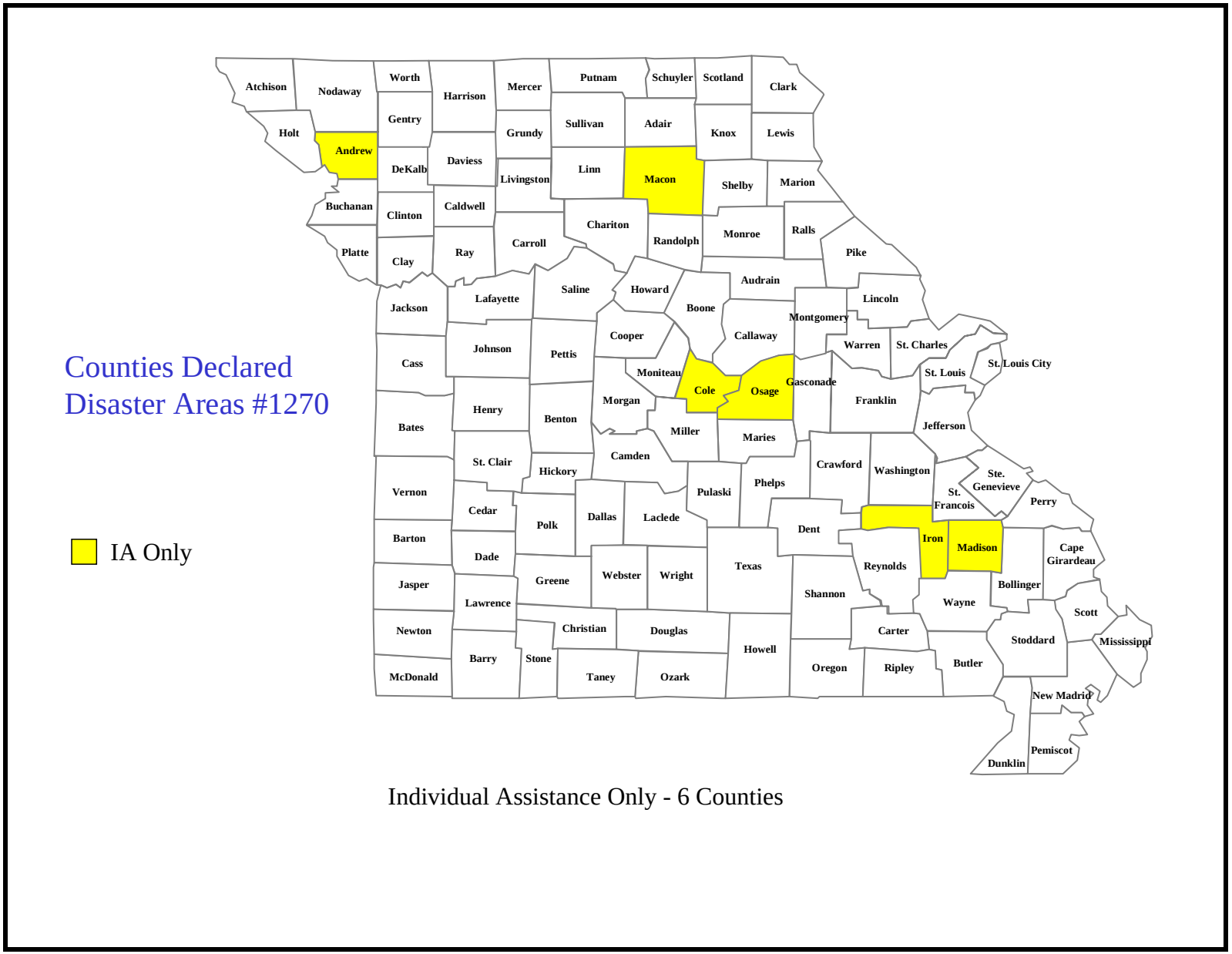
SPRING 2000 FLOOD



Individual Assistance Only - 7 Counties
Individual Assistance and Public Assistance - 3 Counties

Figure 2

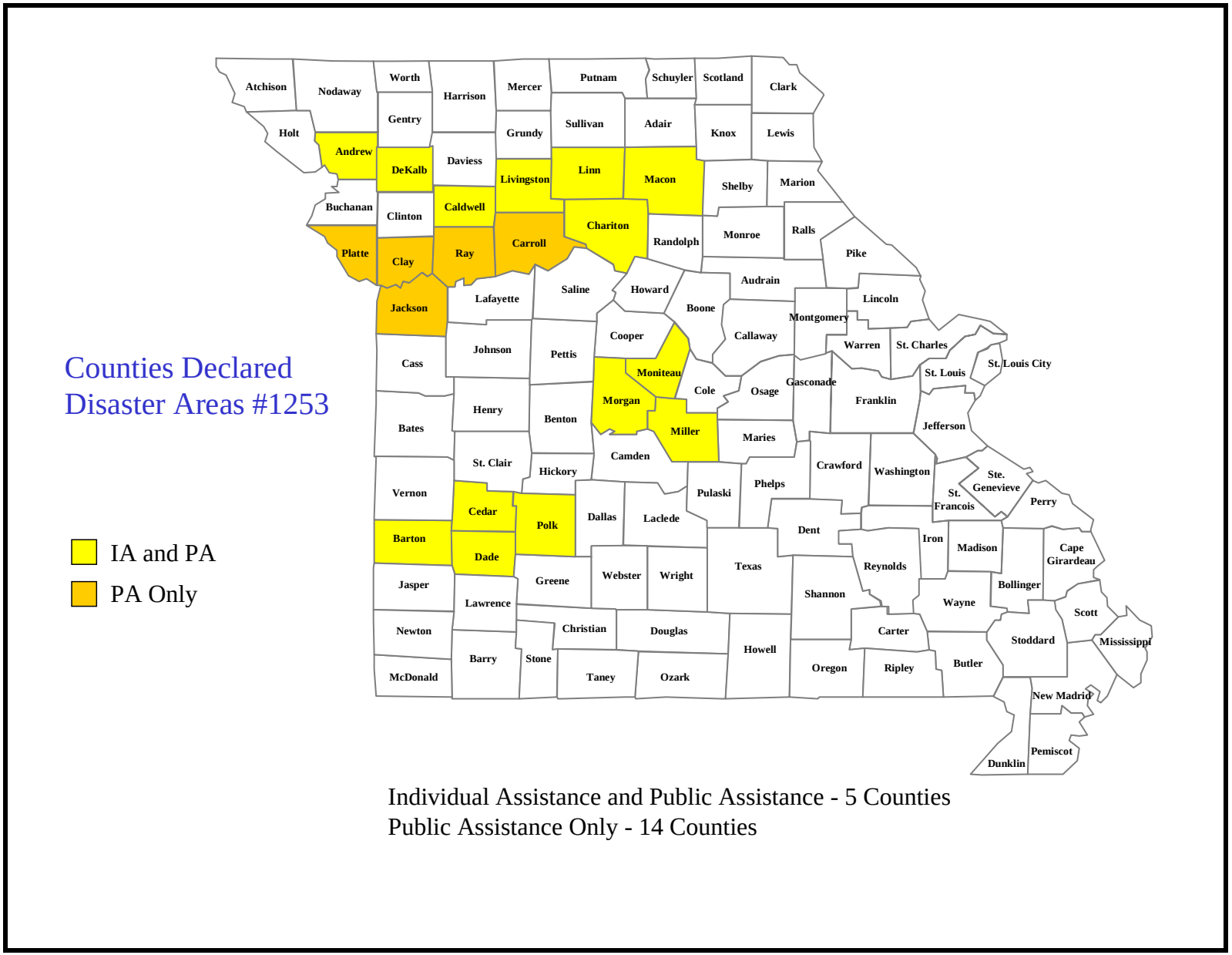
SPRING 1999 FLOOD AND STORMS



Individual Assistance Only - 6 Counties

Figure 3

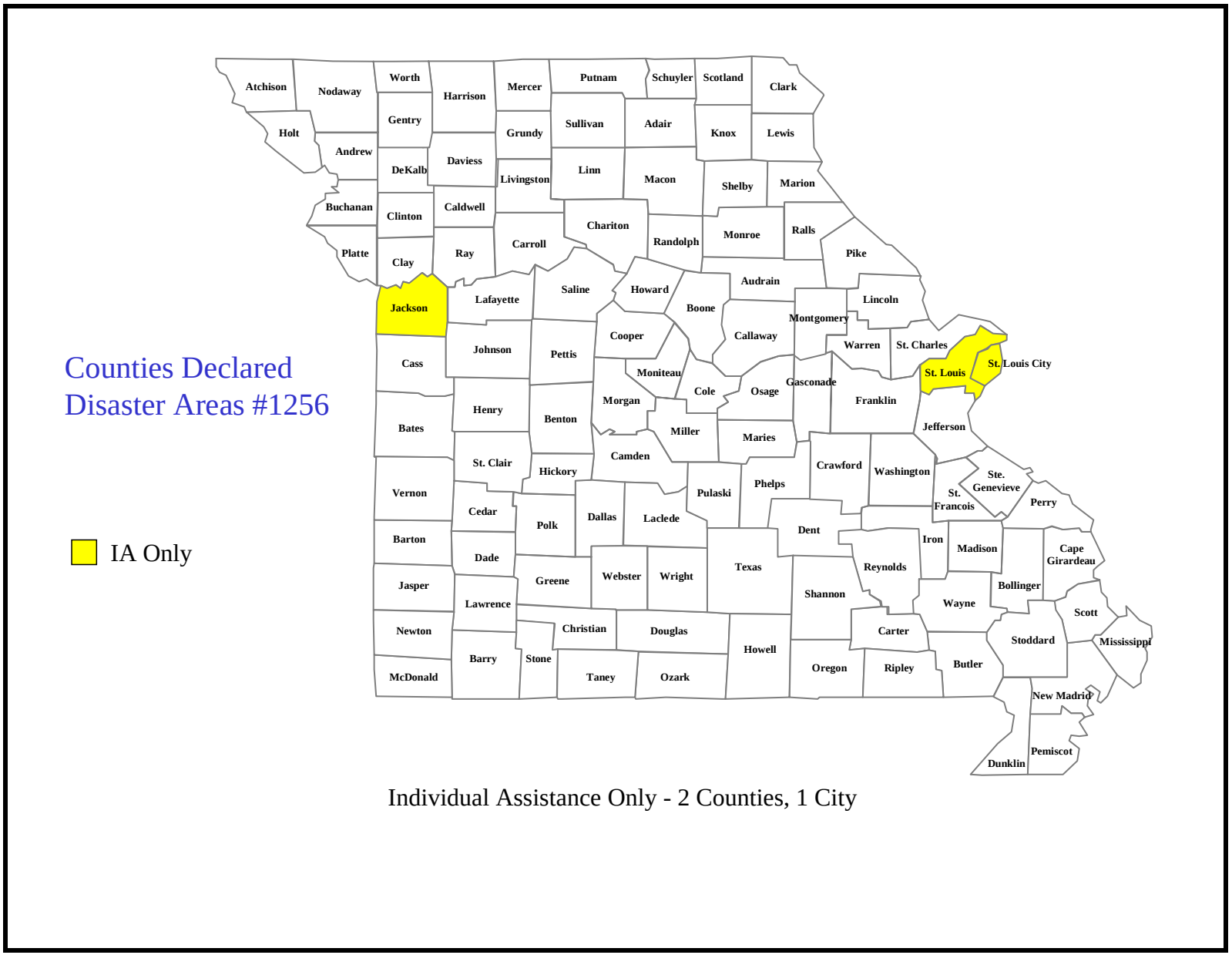
FALL 1998 FLOOD



Individual Assistance and Public Assistance - 5 Counties
Public Assistance Only - 14 Counties

Figure 4

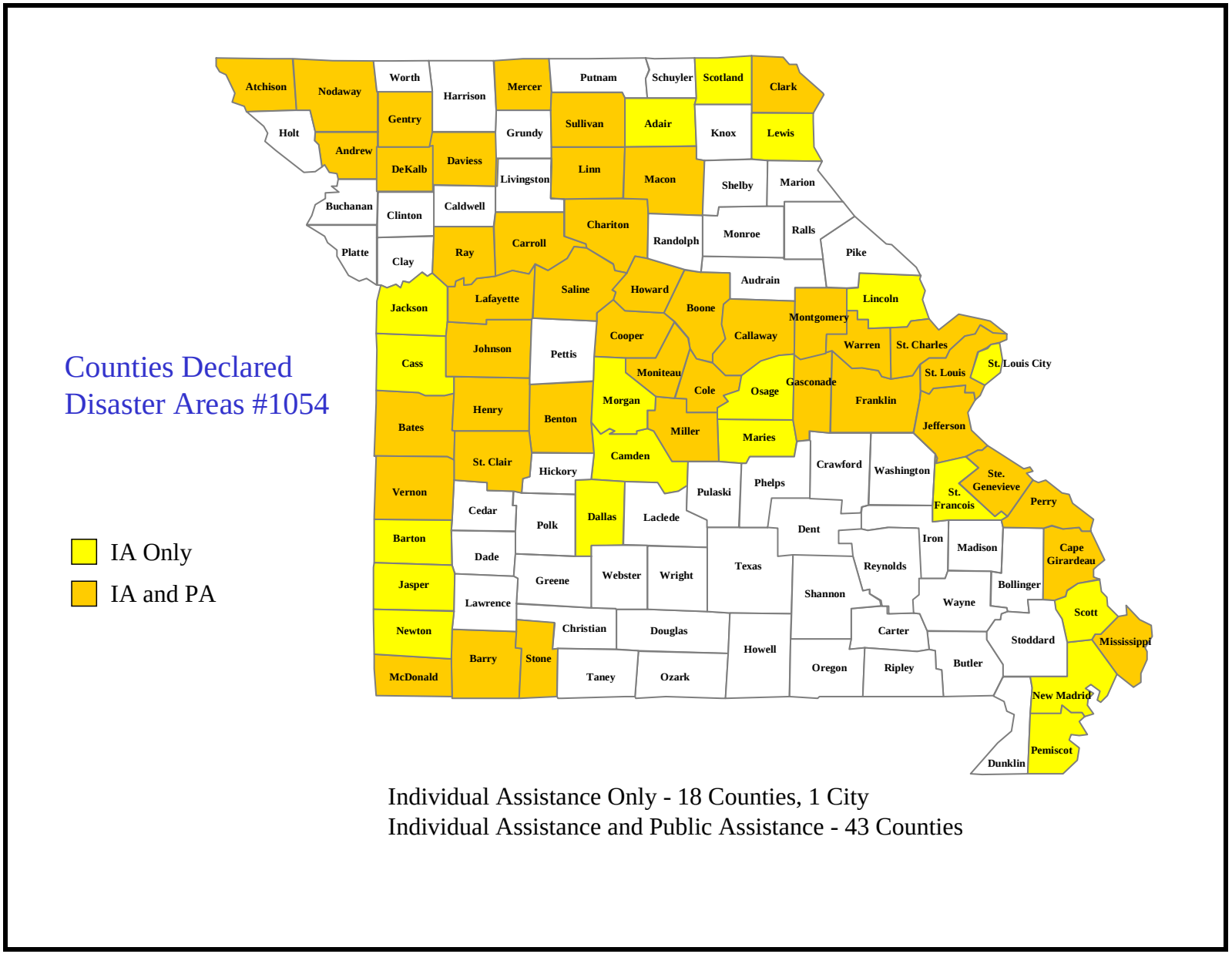
JULY 1998 FLOOD



Individual Assistance Only - 2 Counties, 1 City

Figure 5

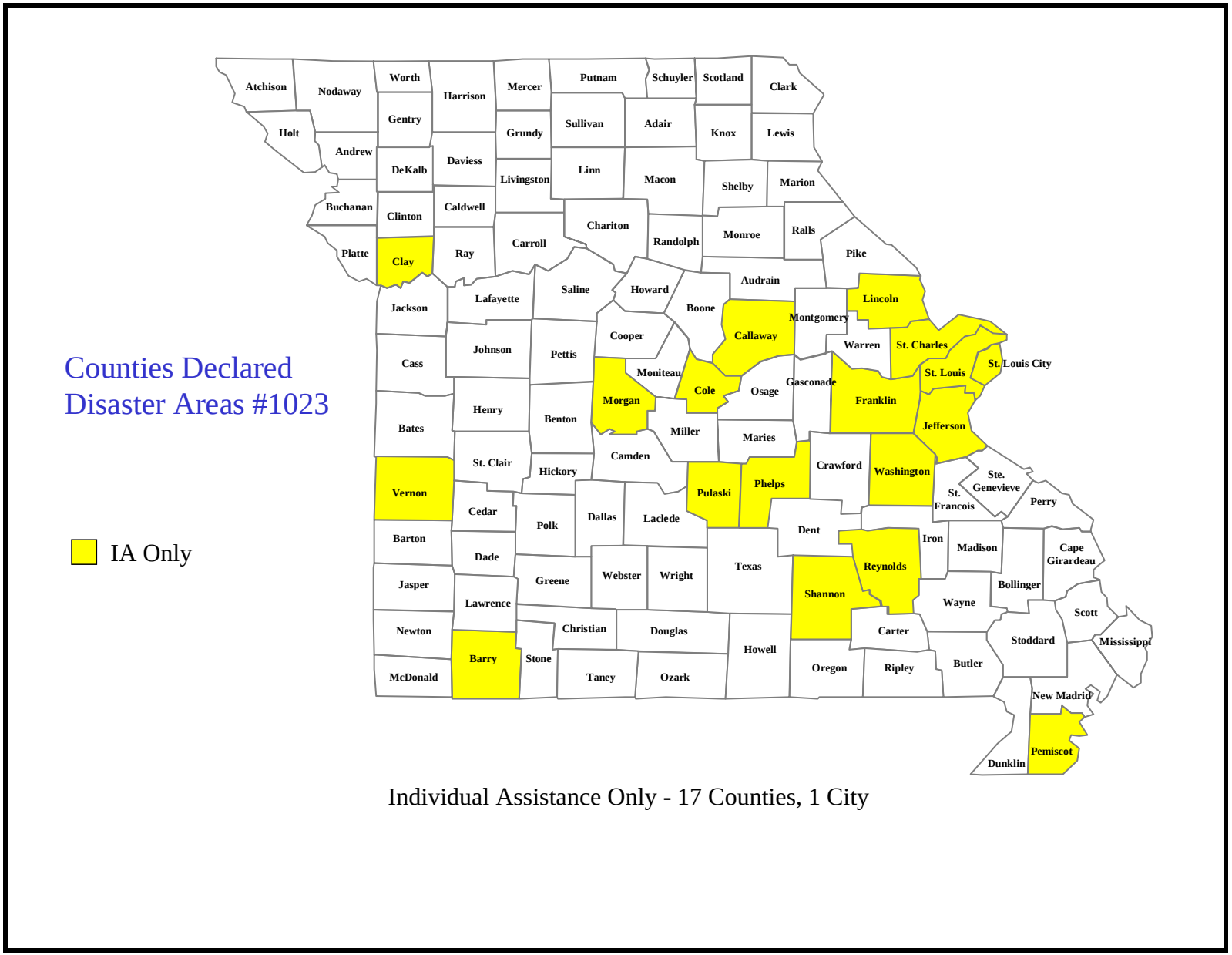
SPRING 1995 FLOOD



Individual Assistance Only - 18 Counties, 1 City
Individual Assistance and Public Assistance - 43 Counties

Figure 6

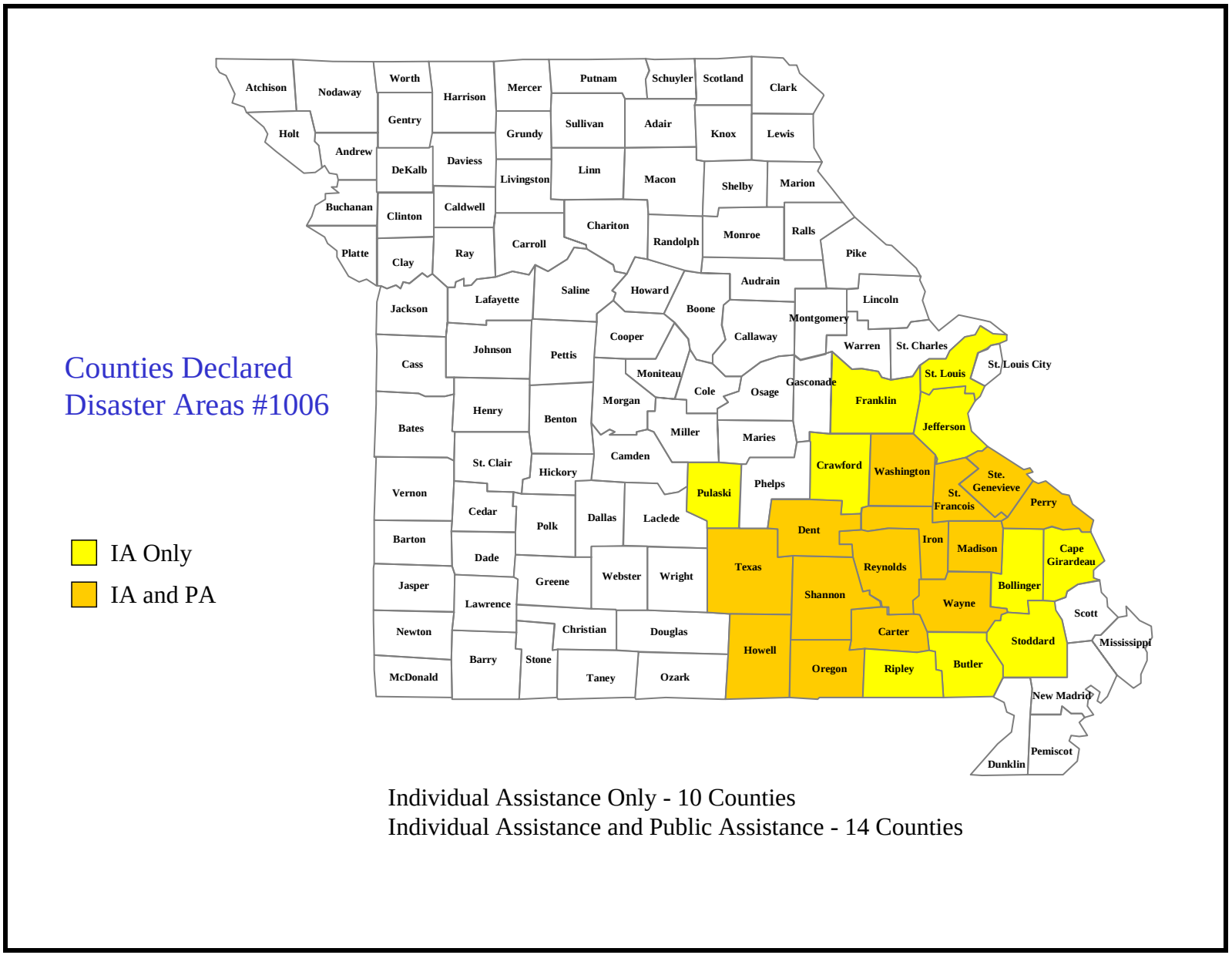
SPRING 1994 FLOOD



Individual Assistance Only - 17 Counties, 1 City

Figure 7

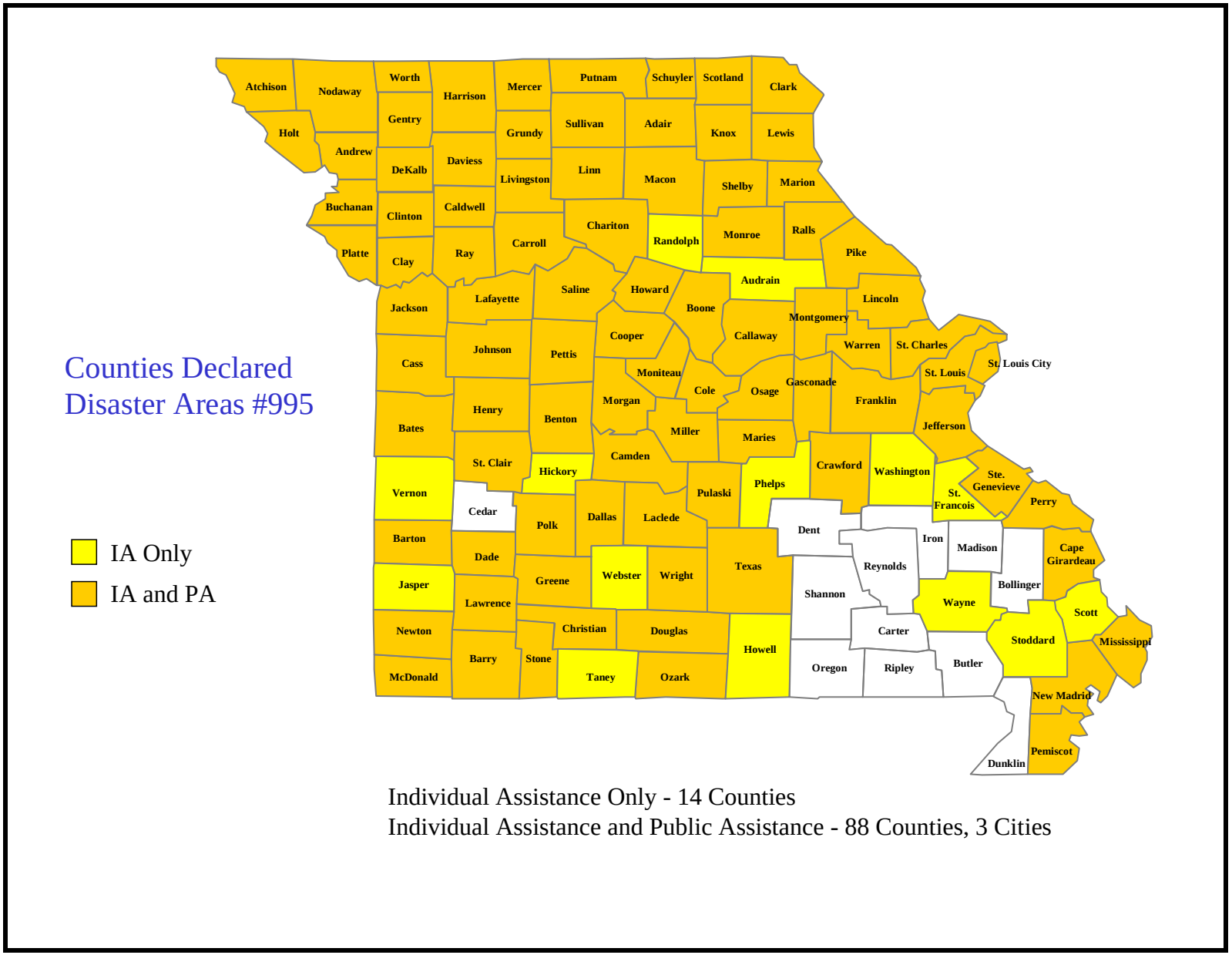
FALL 1993 FLOOD



Individual Assistance Only - 10 Counties
Individual Assistance and Public Assistance - 14 Counties

Figure 8

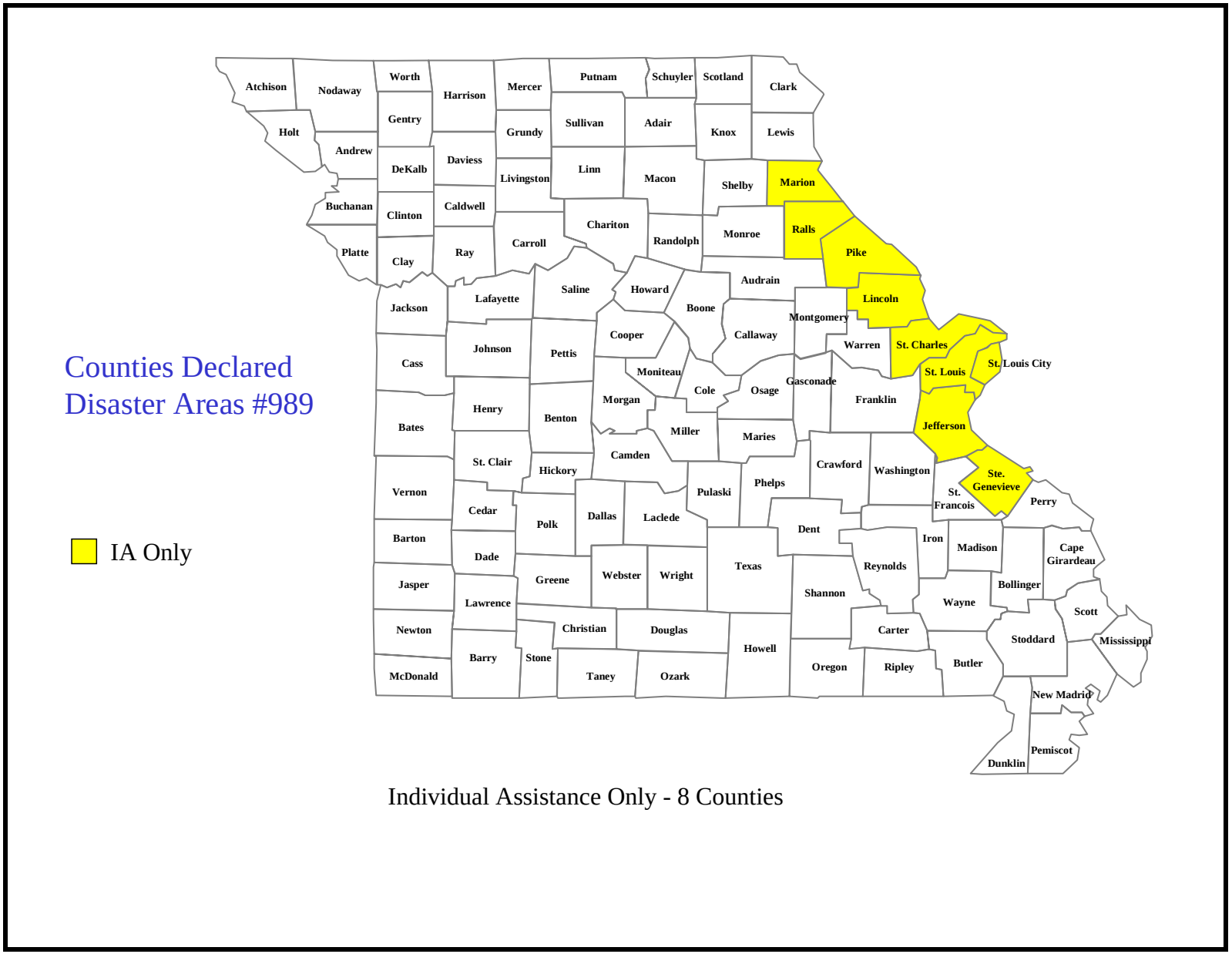
SUMMER 1993 FLOOD



Individual Assistance Only - 14 Counties
Individual Assistance and Public Assistance - 88 Counties, 3 Cities

Figure 9

SPRING 1993 FLOOD



Individual Assistance Only - 8 Counties

Table 1

RECORD HIGH WATER STAGES IN MISSOURI DURING THE SUMMER 1993 FLOOD (IN FEET)

River	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			
St. Joseph	32.7	26.8	17
Kansas City	48.9	46.2	32
Jefferson City	38.6	34.2	23
Hermann	36.3	35.8	21
St. Charles	39.5	37.5	

Source: U.S. Army Corps of Engineers (1993)

Table 2

DISTRIBUTION OF LEVEE FAILURES BY CORPS OF ENGINEERS DISTRICT

NUMBER OF FAILED OR OVERTOPPED LEVEES, SUMMER 1993 FLOOD

COE DISTRICT	FEDERAL LEVEES	NON-FEDERAL LEVEES
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810

* includes eastern Missouri and portions of Illinois

* includes northwestern, west central and portions of southwest Missouri, and areas in Kansas and Nebraska

Note: The difference in the failure rate in the table above is due to the fact that most Federal levees are designed to withstand a 100- to 500-year flood, while non-federal levees, predominantly protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less. **Source: Natural Disaster Survey Report, "The Great Flood of '93."**

Table 3

SUMMER/FALL 1993
CAUSES OF DEATH BY TYPE OF FLOOD

	River Flood	Flash Flood	Total
Motor Vehicle	6 (23%)	20 (77%)	26 (53%)
Drowning	5 (25%)	14 (74%)	19 (39%)
Electrocution	1 (50%)	1 (50%)	2 (4%)
Cardiac	2 (100%)	0	2 (4%)
All Causes	14 (29%)	35 (71%)	49 (100%)

Figure 9

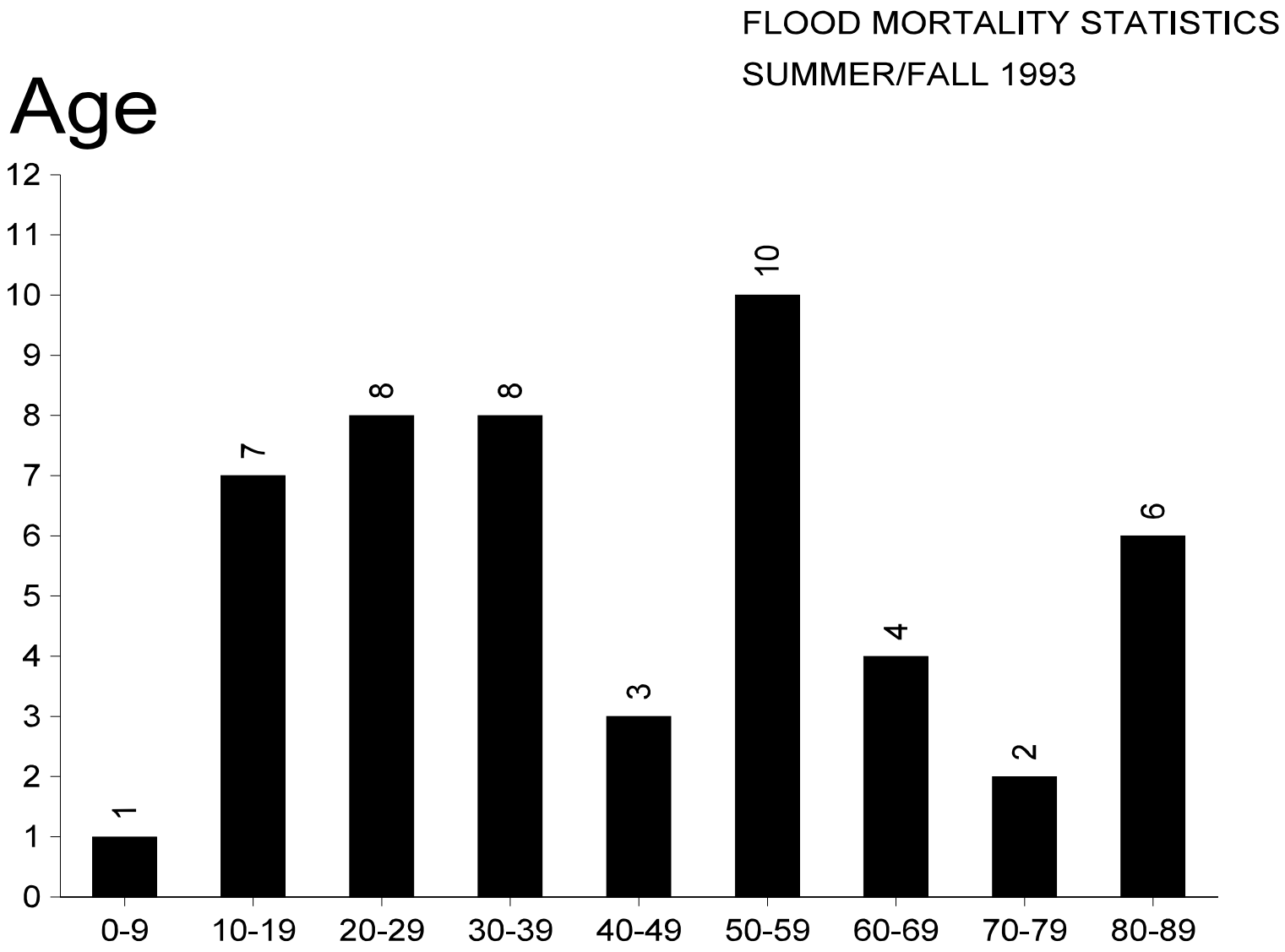

FLOOD MORTALITY STATISTICS
SUMMER/FALL 1993
Age
12
11
10
9
8
7
6
5
4
3
2
1
0
1
7
8
8
3
10
4
2
6
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89

Figure 10

FLOOD MORTALITY STATISTICS
SUMMER/FALL 1993

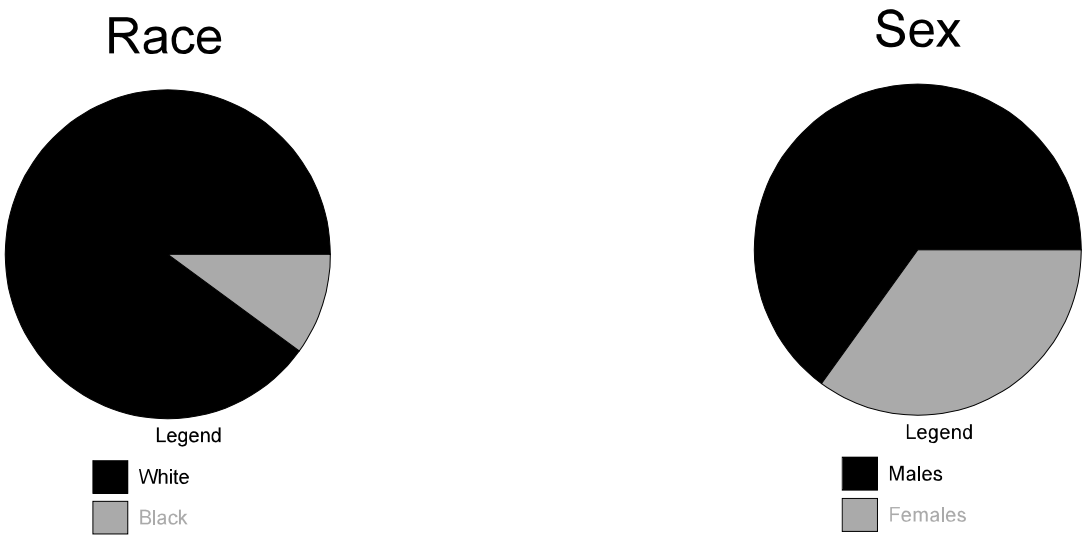
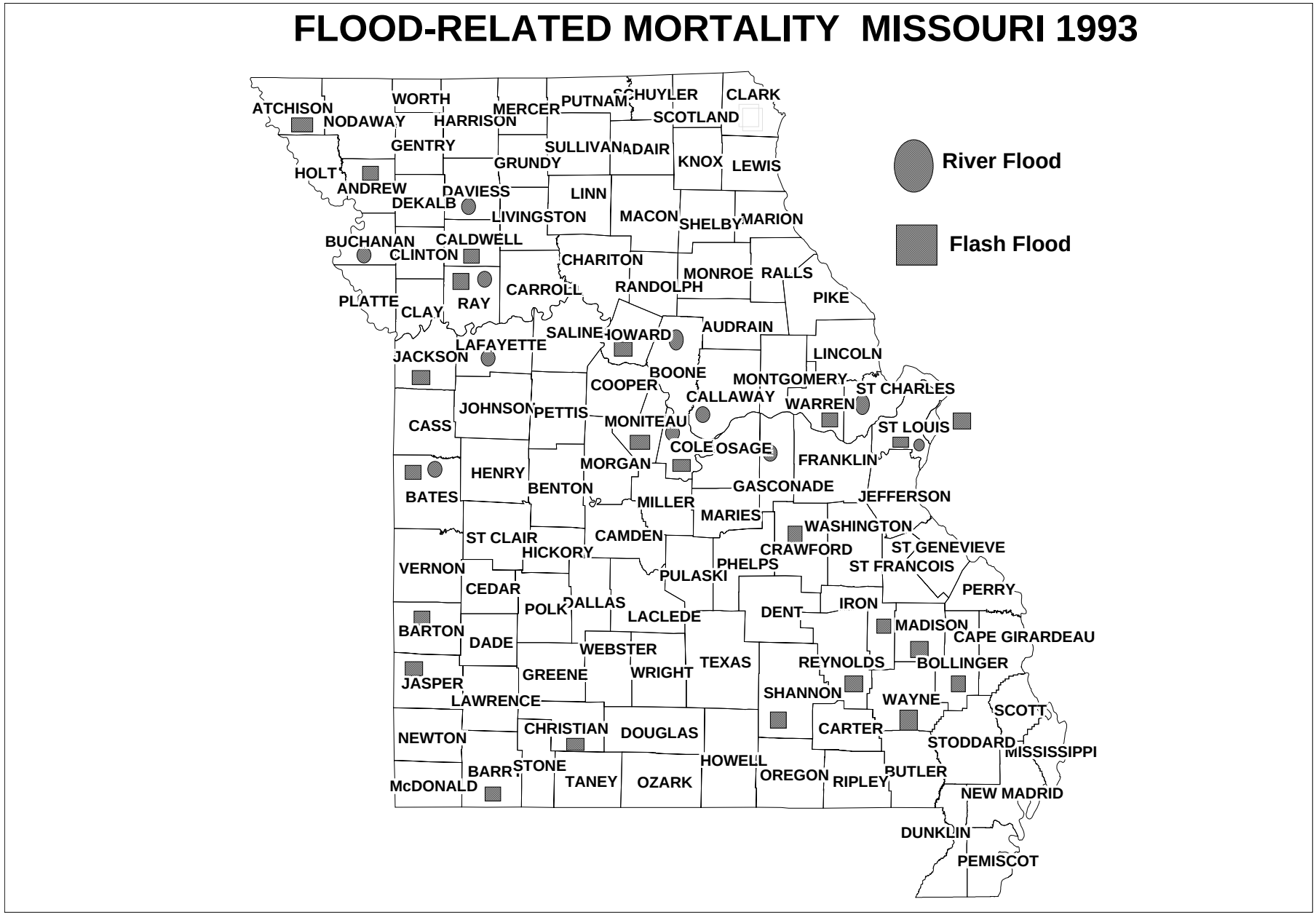


Figure 11


FLOOD-RELATED MORTALITY MISSOURI 1993
River Flood
Flash Flood
ATCHISON
NODAWAY
WORTH
HARRISON
MERCER
PUTNAM
SCHUYLER
CLARK
SCOTLAND
GENTRY
SULLIVAN
ADAIR
KNOX
LEWIS
GRUNDY
HOLT
ANDREW
DAVIESS
DEKALB
LINN
LIVINGSTON
MACON
SHELBY
MARION
BUCHANAN
CALDWELL
CLINTON
CHARITON
MONROE
RALLS
CARROLL
RANDOLPH
PIKE
PLATTE
CLAY
RAY
AUDRAIN
SALINE
HOWARD
LAFAYETTE
JACKSON
LINCOLN
BOONE
COOPER
MONTGOMERY
ST CHARLES
CALLAWAY
WARREN
JOHNSON
PETTIS
MONITEAU
ST LOUIS
CASS
COLE
OSAGE
FRANKLIN
MORGAN
HENRY
GASCONADE
BENTON
JEFFERSON
BATES
MILLER
MARIES
WASHINGTON
ST CLAIR
CAMDEN
CRAWFORD
ST GENEVIEVE
HICKORY
PHELPS
ST FRANCOIS
VERNON
PULASKI
CEDAR
PERRY
DALLAS
IRON
POLK
LACLEDE
DENT
MADISON
BARTON
CAPE GIRARDEAU
DADE
WEBSTER
TEXAS
REYNOLDS
BOLLINGER
GREENE
WRIGHT
JASPER
SHANNON
WAYNE
LAWRENCE
SCOTT
CHRISTIAN
DOUGLAS
CARTER
NEWTON
STODDARD
MISSISSIPPI
HOWELL
STONE
BARRY
OREGON
RIPLEY
BUTLER
McDONALD
TANEY
OZARK
NEW MADRID
DUNKLIN
PEMISCOT

ANNEX C

SEVERE WINTER WEATHER
(SNOW, ICE, AND EXTREME COLD)

I. TYPE OF HAZARD

Severe Winter Weather (Snow, Ice, and Extreme Cold)

II. DESCRIPTION OF HAZARD

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. The greatest threat is likely to occur in the area north of the Missouri River, as with the devastating Kansas City area ice storm on January 31, 2002, which stretched into central Missouri and led to a Presidential Disaster Declaration. Severe weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways. Winter storms are considered deceptive killers. This is because most deaths are indirectly related to the storm. Causes of death range from traffic accidents due to adverse driving conditions such as icy roads, to heart attacks caused by overexertion while shoveling snow and from other related activities. Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold. Economic costs are also difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines, and communications towers. Such power outages create an increased risk of fire, as home occupants use alternative fuel sources (wood, kerosene, etc. for heat, and fuel-burning lanterns or candles for emergency lighting). These storms can also affect utility and city operations due to debris removal and landfill hauling. In the 2002 ice storm, one home burned when ice-laden tree limbs fell and tore the electrical junction box from the outside of the home. Electrical sparks ignited a blaze that destroyed the home. Crops and trees can be damaged, and livestock can be killed or injured due to deep snow, ice, or severe cold. Buildings and automobiles may be damaged from falling tree limbs, power lines, and poles. Local governments, home and business owners, and power companies were faced with spending millions of dollars to restore services, remove debris, and haul debris. Federal public assistance for local governments and individual assistance for citizens and businesses under Presidential Disaster Declaration MO-DR 1403 helped cover much of the expense. (See storm synopsis under Section III, Historical Statistics.)

The types of watches and warnings during severe winter weather are listed below:

Winter Weather Advisory	Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
Winter Storm Watch	Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
Winter Storm Warning	Severe winter conditions have begun or are about to begin.
Blizzard Warning	Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.

III. HISTORICAL STATISTICS

Weather data indicate that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable. The degree of severity may be localized to a small area due to a combination of climatic conditions.

Besides snow and ice, extremely cold temperatures can produce problems. The wind chill is determined from cold temperatures combined (see Table C-1). For example, when the temperature is 20 °F and the wind speed is 15 mph, the resulting wind chill (what it really feels like) is 6 °F. This type of situation can be dangerous to people outdoors because their bodies can experience rapid heat loss and thus cause hypothermia (abnormally low body temperature). Statistical information regarding hypothermia mortality is provided on Figure 2 at the end of this annex.

An indirect winter hazard that affects Missourians every year is carbon monoxide poisoning. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes creates dangerous levels of carbon monoxide. In 1997, 31 cases of carbon monoxide poisoning were reported in Missouri. No deaths were reported from these cases.

The following summaries describe some of the more severe winter weather that has occurred in Missouri in recent years. (This information was taken from the National Weather Service's "Storm Data and Unusual Weather Phenomena" publication.)

February 15-16, 1993: Central and southern Missouri was covered with up to 21 inches of snow. The airport at Cape Girardeau received 6 inches of snow in 1 hour and 20 minutes.

January 14-20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20 °F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50 °F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 16-17, 1994: A layer of ice up to 2 inches thick formed over sections of southeast Missouri, followed by 6 to 10 inches of snow. Some areas were without power for more than 24 hours. Roofs collapsed due to the heavy weight of snow and ice.

December 6, 1994: Ice accumulations of 0.5 to 1.0 inch were reported across northwest, north-central, and northeast Missouri. Over 75 percent of the residents in this region were without power. Phone and cable television was also out. A few rural areas were without power for at least seven days. The City of St. Joseph was declared a disaster area by Governor Mel Carnahan because of damages totaling nearly $4 million.

January 18-19, 1995: Central Missouri received heavy snows, dumping 19.7 inches over Columbia alone and setting a new 24-hour snowfall record. Parts of I-70, I-44, and other major highways were closed due to drifting snow. Snow fell at such a fast rate that snowplows and graders became stuck. Almost 5,000 birds were killed when several large chicken and turkey barns collapsed. Thousands of people were without power and telephone service. The Jefferson City and Columbia airports were closed for a time. The University of Missouri at Columbia canceled classes for the first time in nearly 17 years. State offices in Jefferson City were also closed.

October 22-23, 1996: An early snowfall hit the Kansas City area, dumping as much as 8.5 inches of heavy wet snow. Approximately 130,000 residences were without power, and an estimated $1.5 million in property damages were reported.

January 10-13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 mph produced afternoon wind chills as low as -30 to -50 °F.

April 10-11, 1997: A spring snowstorm dumped up to 24 inches in extreme north Missouri. Schuyler County alone reported $2 million in damages, most due to the heavy snow causing roofs on farm buildings to collapse.

January 31, 2002: A massive severe winter storm system dumped snow and ice from Oklahoma to Kansas and into central and northern Missouri. In Missouri alone, more than 600,000 residents were without power, as ice-encased power lines snapped in fierce winds or were pulled down by falling trees and limbs. Loss of electricity included more than 460,000 people in the Kansas City metro area alone (Jackson, Cass, Clay, and Platte counties). Additionally, residents in a line from Kansas City to the Iowa-Illinois border were without power as rural electric cooperative lines broke as well. Outages ranged from several days to nearly two weeks. Damage to property, power restoration, and the cost of debris removal for local governments was so high that Missouri received a Presidential Disaster Declaration (MO-DR 1403) on February 6, 2002, which ultimately included 43 counties; 26 were designated for both individual and public assistance, and 17 were eligible for individual assistance only. (For a list of all counties declared, see Figure 1 in Section VII.) The total eligible public assistance costs for this disaster ($61.9 million dollars as of August 2002) ranks the 2002 ice storm as Missouri's second most costly disaster to date.

IV. MEASURE OF PROBABILITY AND SEVERITY

It is quite difficult to make an objective and quantitative measure of the probability and severity of snowstorms, ice storms, and extreme cold. Therefore, any analysis should be considered subjective and qualitative.

For areas north of the Missouri River, the probability of a snowstorm, ice storm, or extreme cold should be considered high due to historically higher average snowfall and lower average temperatures. However, the severity is rated moderate due to the overall level of preparedness in this area. For example, homes and businesses may be better insulated due to the higher probability of severe cold relative to other areas. Also, people living in this area may be more likely to use snow tires or purchase four-wheel-drive vehicles. People living in this area may be more likely to maintain adequate supplies of home heating fuels and consider other preparedness measures. Local and state governments may have access to more snow clearing equipment and maintain adequate supplies of materials needed for snow or ice removal. School districts and businesses may be more likely to develop and use snow routes or establish closing procedures.

Areas south of the Missouri River have a low probability of a snowstorm, ice storm, or extreme cold due to their lower average snowfalls and temperatures. However, such events in these areas have a moderate potential severity. This may be due to a lower level of preparedness. People living in this area may have homes with inadequate insulation or fail to maintain an adequate supply of home heating fuels. People may be less likely to equip their vehicles with snow tires or purchase four-wheel-drive vehicles. Local and state governments may not maintain sufficient amounts of equipment and materials. Schools and businesses may not have formal snow routes or closing procedures.

V. IMPACT OF THE HAZARD

People are adversely affected by winter storms, ice storms, and extreme cold, some more than others. Observations by the National Oceanic and Atmospheric Administration (NOAA) indicate that of winter deaths related to exposure to cold, 50 percent were over 60 years old, over 75 percent were male, and about 20 percent occurred in the home. Of winter deaths related to ice and snow, about 70 percent occur in automobiles, and 25 percent are people caught in storms. As noted earlier, ice storms can result in significant economic costs to homeowners, business owners, and utility companies. The ice storm in December 1994 has shown the environmental damage that can occur. Thousands of trees and plants were cut down or damaged as a result of the ice storm. The problem of debris clearance caused environmental impacts due to the permitted burning of debris or reduced landfill space.

VI. SYNOPSIS

As noted in this report, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow or a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

VII. MAPS OR OTHER ATTACHMENTS

(MO-DR 1403): Counties declared for individual assistance and public assistance from the January 2002 ice storm are shown on Figure C-1.

Fatalities from Hypothermia: Hypothermia became reportable by law in Missouri effective April 8, 1993. Hypothermia is defined as a physician-diagnosed case of cold injury associated with a fall of body temperature to less than 94.1 °F and resulting from unintentional exposure to a cold environment.

From 1991 through 2002, 132 Missourians died from conditions related to excessive cold. The most severe winters were 1995-96 when 20 deaths occurred, and 2000-2001 when 19 deaths were recorded (see Figure C-2). Fifty-two percent of the total hypothermia deaths occurred in persons aged 65 and over. The rate of mortality increased sharply at older ages. This emphasizes the need to provide support and assistance to persons at highest risk.

New Wind Chill Chart: In 2001, the National Weather Service implemented a replacement Wind Chill Temperature (WCT) index for the 2001-2002 winter season (see Table C-1). The reason for the change was to improve the current WCT index used by the NWS and the Meteorological Services of Canada (MCS, the Canadian equivalent of the NWS), which was based on scientific research and a previous index from 1945.

The new formula makes use of advances in science, technology, and computer modeling to provide a more accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. In addition, clinical trials have been conducted, and the results of those trials have been used to verify and improve the accuracy of the new formula. The new WTC index incorporates the following factors:

- Uses wind speed calculated at the average height (5 feet) of the human body's face, instead of 33 feet (the standard anemometer height)
- Is based on a human face model
- Incorporates modern heat transfer theory (heat loss from the body to its surroundings during cold and breezy/windy days)
- Lowers the calm wind threshold to 3 mph
- Uses a consistent standard for skin tissue resistance
- Assumes the worst-case scenario for solar radiation (clear night sky).

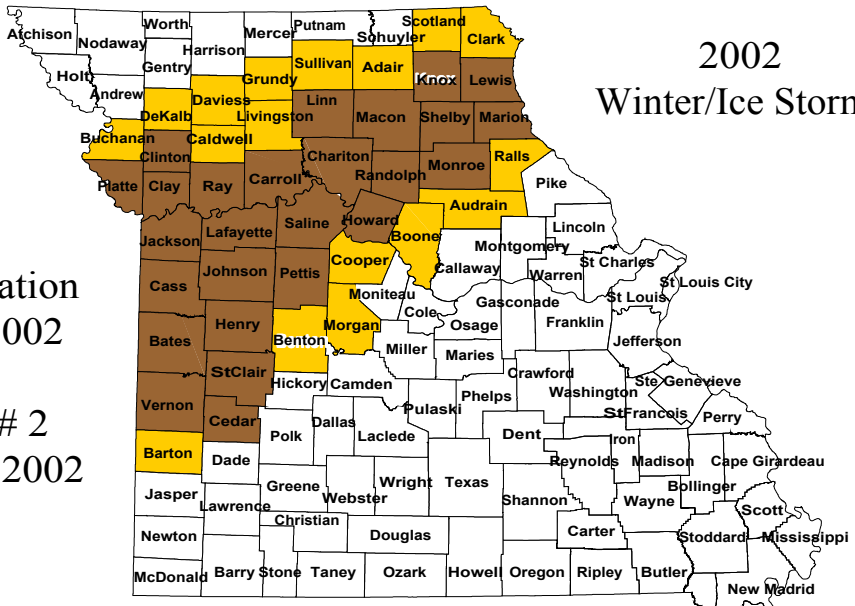
FIGURE C-1

DR-1403 Presidential Declaration

2002
Winter/Ice Storm

Initial Declaration
February 6, 2002

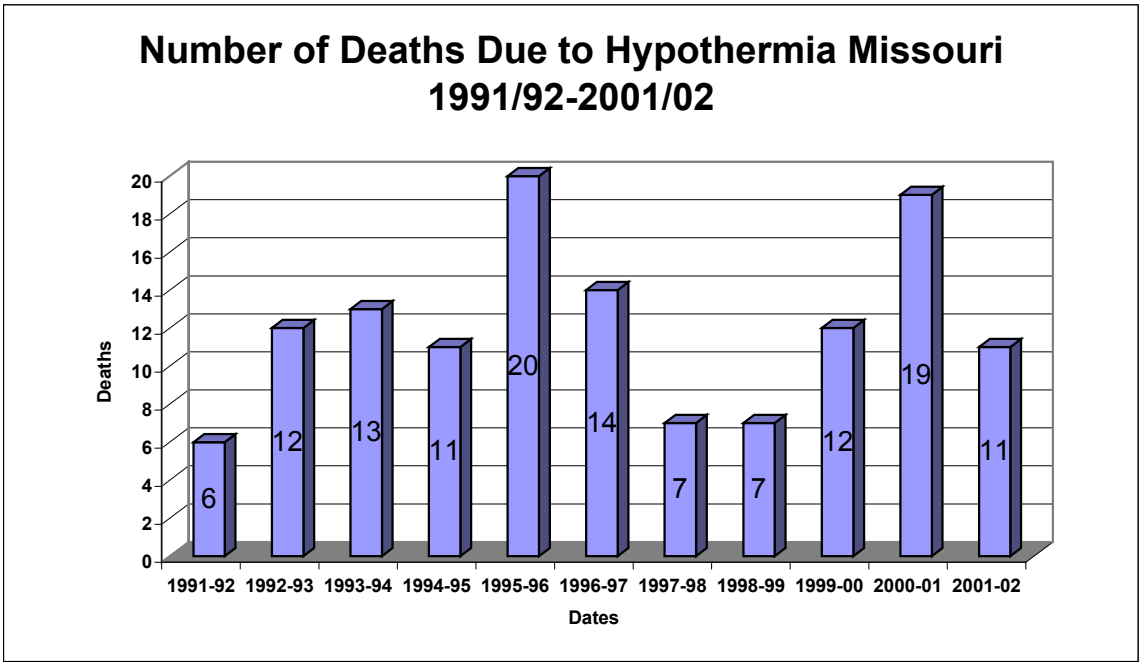
Amendment # 2
February 15, 2002



26 Public Assistance & Individual Assistance

17 Individual Assistance Only

FIGURE C-2



Source: Missouri Department of Health and Senior Services

TABLE C-1

Wind Chill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

VIII. BIBLIOGRAPHY

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DROUGHT

I. TYPE OF HAZARD

Drought

II. DESCRIPTION OF HAZARD

Drought is not limited to a hazard that affects just farmers, but can extend to encompass the nation's whole economy. Its impact can adversely affect a small town's water supply, the corner grocery store, commodity markets and a big city's tourism. On average, drought costs the U.S. economy about $7-$9 billion a year, according to the National Drought Mitigation Center. While there's no cost estimate for the current Drought of 1999-2000 which has gripped Missouri and the much of the nation, losses from the Great Drought of 1988-'89 have been assessed at $39 billion.

The dictionary definition of drought is a period of prolonged dryness. Current drought literature commonly distinguishes between three "categories" of drought, all of which define drought in simplified terms:

1. **Agricultural Drought**, defined by soil moisture deficiencies.

2. **Hydrological Drought**, defined by declining surface and groundwater supplies, and

3. **Meteorological Drought**, defined by precipitation deficiencies.

Each of these definitions relates the occurrence of drought to water shortfall in some component of the hydrological cycle. Each affects patterns of water and land use, and each refers to a repetitive climatic condition. In urban areas, drought can affect those communities dependent on reservoirs for their water, as decreased water levels due to insufficient rain can lead to the restriction of water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield.

To take the definition of drought even further, the U.S. Government definition of an agricultural drought incorporates specific parameters based upon historical records. Agricultural drought is "a combination of temperature and precipitation over a period of several months leading to a substantial reduction in yield (bushels per acre) of one or more of the three major food grains (wheat, soybean, corn). A substantial reduction is defined as a yield (bushels per acre) less than 90% of the yield expected with temperature/precipitation equal to long term average values."

Regardless of the specific definition, droughts are difficult to predict or forecast both as to when they will occur, and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri-Columbia, there is a recognizable "upper air flow pattern and simultaneous surface pattern associated with abnormal dryness over Missouri." When the upper air flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the U.S., then the air over the southern plains will be "characterized by a weak clockwise circulation." "Storm systems coming off the Pacific Ocean" will cross the extreme northwestern states and southern Canada, thus bypassing the midwestern states. When this flow pattern persists, the result can be a prolonged period of drought.

The most commonly used indicator of drought and drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA). The PDSI measures the departure of water supply (in terms of precipitation and stored soil moisture) from demand (the amount of water required to recharge soil and keep rivers, lakes and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and .5 intervals. By relating the PDSI number to a regional index, one can compile data which reflects long-term wet or dry tendencies.

Above 4.0	Extreme Moist Spell
3.0 to 3.9	Very Moist Spell
2.0 to 2.9	Unusually Moist Spell
1.0 to 1.9	Moist Spell
0.5 to 0.9	Incipient Moist Spell
0.4 to -0.4	Near Normal Conditions
-0.5 to -0.9	Incipient Drought
-1.0 to -1.9	Mild Drought
-2.0 to -2.9	Moderate Drought
-3.0 to -3.9	Severe Drought
Below -4.0	Extreme Drought

Missouri is divided into six regions of similar climatic conditions for reporting purposes of the PDSI: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel. These regions are illustrated on the map (Palmer Drought Severity Index, Missouri Subregions), in Section VII of this annex.

In addition to the NOAA/USDA indices, water management agencies in Missouri have access to the Missouri Crop and Weather Report, produced by the Missouri Agricultural Statistics Service. These reports provide detailed statistical information on weather conditions, crop conditions, topsoil moisture supply and subsoil moisture supply by subregion throughout Missouri.

Other less conceptual indicators of drought include: measuring water demand versus supplies available, reductions in streamflow, declining reservoir levels, precipitation deficits, falling water levels in wells, and soil moisture supply.

The difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset. Regional indicators such as the Palmer Index are limited in that they respond slowly to deteriorating conditions, whereas observing surface conditions and groundwater measurements, or rainfall, may only provide a "snapshot" of a very small area.

Consequently, the use of a variety of drought indicators is essential for effective assessment of drought conditions, with the Palmer Index being the primary means to assess drought severity.

III. HISTORICAL STATISTICS

Missouri's average annual rainfall ranges from about 34 inches in the northwest to about 48 inches in the southeast. Even the driest areas of Missouri have enviable rainfall, compared to most

western states. But lack of rainfall impacts certain parts of the state more than others because of alternate sources and usage patterns.

SOUTHERN MISSOURI - Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods of non rain, since there is abundant groundwater resources. Even with decreased streamflow or lowered reservoir levels, groundwater is still a viable resource in southern Missouri. Row-crop farming is not extensive and therefore agricultural needs aren't as great as in other parts of the state. The only exception is in the southwestern and southeastern areas where irrigation is used.

NORTHERN AND WEST CENTRAL MISSOURI - Most of the northern and west central portions of Missouri is underlain by rocks which are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the state, irrigation is generally not feasible - except on the floodplains of major rivers.

Drought of 1999-2000

Most of Missouri was in a drought condition during the last half of 1999, along with other states in the Midwest and the nation. The dryness did not begin to evolve until July '99, but rapidly developed into a widespread drought by September. At that time, Missouri was placed under a Phase I Drought Advisory level by the Department of Natural Resources (DNR), and Governor Carnahan declared an Agricultural Emergency for the entire State. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri's top cash crop - soybean. On October 13, 1999, U.S. Agriculture Secretary Dan Glickman declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November '99. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.

A wetter than normal winter diminished dry conditions in central and southern Missouri, but long-term moisture deficits continued to exist. At the same time, the remainder of the state (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the state in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire State was under a Phase II Drought Alert level, and on May 23rd, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by the DNR Director. At a May 25th meeting, the DAC selected a subcommittee (guided by the Missouri Drought Response Plan) to determine the drought status of each county. Based on observations across the state and projections of future

rainfall, the committee in June upgraded the drought status for 27 northern Missouri counties to Phase III, Conservation. (See Missouri Drought Conditions Map, figure 3.) This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected for water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while seven counties in Southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemscot, Scott and Stoddard) remained under Phase I, Advisory conditions.

By mid-July 2000, some areas of northern Missouri benefitted from additional rainfall, while drier conditions prevailed in other areas. At its July 12th meeting, the DAC revised its assessment, placing 30 counties under Phase 3 Conservation, including 10 counties in the south central area. The remaining 84 counties in the state were all under Phase 2, Drought Alert. This included 7 counties in northern Missouri downgraded from Phase III Conservation, and 7 counties in Southeast Missouri previously assessed as Phase I, Advisory. (See Missouri Drought Conditions Map, figure 4.)

To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over 1 million acres from the Conservation Reserve Program (CRP) to allow farmers and ranchers in 21 counties an additional source to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.

IV. MEASURE OF PROBABILITY AND SEVERITY

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions, as is the Western Great Plains area. Agricultural droughts are the most common of record, particularly those inflicting damage to corn crop yields. Throughout much of this century, these droughts have occurred with common regularity (on the average of once every five years), according to the Missouri Crop and Livestock Reporting Service.

Based on a collection of Midwest drought data and evaluation work by its staff, the Missouri Department of Natural Resources (Water Resources Program) has produced a Missouri Drought Response Plan (1995). The plan's primary purpose is to address the need for coordinated advanced emergency planning for state and local government, as used during the Drought of '99-2000. The plan outlines proactive emergency and tactical measures designed to better prepare the State for drought. It also emphasizes the need for long-range strategic planning, which would address the bigger issue of drought impact avoidance. Preventing water shortages in public water systems is considered one of the major goals of drought mitigation, as noted in the plan.

In preparing this document, DNR divided the state into three regions which are prioritized according to drought susceptibility. The regions are identified as having **SLIGHT, MODERATE, and SEVERE** susceptibility to drought conditions. They are illustrated on the map (Drought Susceptibility) in Section VII of this annex. A description of the drought susceptibility for the three regions are as follows:

REGION A (mostly Southeast Missouri) has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are

generally adequate for domestic, municipal, and agricultural needs. During the Drought of '99-2000, for example, counties in this area remained in the lowest drought stage (Phase I, Advisory Level) from the fall of '99 until mid-July, 2000 when the DAC assessed area conditions as Phase II, Alert Level with most other areas of the state.

REGION B (Central/East Central Missouri) has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography generally is unsuitable for row-crop irrigation.

REGION C (Northern/West Central Missouri; St. Louis County) has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. The groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources. During the Drought of '99-2000, 20 to 27 counties in the northern portion of this region were rated as Phase III, Conservation Level during June and July 2000.

The Missouri Drought Response Plan relies primarily upon the Palmer Index to indicate drought severity, and supports its findings directly with streamflow, reservoir-level and groundwater-level measurements. Actions within the drought plan are triggered when the Palmer Index reaches certain levels. The Drought Assessment Committee (DAC), chaired by the Director of the Department of Natural Resources, is activated in the Phase II Drought Advisory Stage. The DAC then activates the Impact Task Forces, which cover the topics of Agriculture, Natural Resources and Environmental Recreation, Water Supplies and Wastewater, health, Social, Economic, and Post Drought Evaluation. Areas which appear to be the most vulnerable to drought are the focus of future drought planning, management and mitigation activities. **Based on this information, the State rates the probability and severity of the drought hazard as moderate.**

V. IMPACT OF THE HAZARD

A severe drought in the Southern Plains states from the Fall of 1995 through the Summer of 1996 resulted in more than $4.0 billion in costs and damages to agricultural regions. The States of Texas and Oklahoma were most severely affected. In the Summer of 1993, a combination of drought and heat wave across the Southeast U.S. was responsible for about $1 billion in costs and damages. Among the most costly disasters, however, was the Great Drought of 1988-89, which caused an estimated $39 billion in losses in the United States. As a comparison, the record floods of 1993 in the Midwest inflicted damage in the range of $12 to $16 billion. Although more subtle in terms of physical damage, the social and economic costs of drought are substantial.

Drought, as it affects the citizens of Missouri in terms of health and safety, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems in the past that have impacted some of the smaller communities. Most seriously affected are those supplied by small water structures. In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of

resources and other response issues. Good water quality and a plentiful supply are two factors in daily life which are often taken for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. The State Water Resources Plan (RSMO 640.415), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires the Department of Natural Resources to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance and periodic updating of a long-range comprehensive statewide plan for the use of surface and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs.

VI. SYNOPSIS

In addition to damage to crops, produce, livestock, soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk to fire. The danger is especially high for brush fires, grass fires and those in wooded areas which can threaten homes and other structures in their path. During the spring 2000 drought, brush and wildfires erupted in numerous counties, resulting in a Governor's State of Emergency. The fires in Camden County were the most severe (See Fires, Annex I, in this State Hazard Analysis). Lack of water resources in rural areas can complicate the firefighting effort.

Severe drought also poses health threats to citizens due to water shortages and the extreme heat. Particularly vulnerable are children, the elderly and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures also cause a variety of serious illnesses.

VII. MAPS OR OTHER ATTACHMENTS

Figure 1 - Palmer Drought Severity Index
Figure 2 - Drought Susceptibility
Figure 3 - Missouri Drought Conditions, June 1, 2000
Figure 4 - Missouri Drought Conditions, July 17, 2000

PALMER DROUGHT SEVERITY INDEX

MISSOURI SUBREGIONS

Figure 1

ANNEX E

HEAT WAVE

I. TYPE OF HAZARD

Heat Wave

II. DESCRIPTION OF HAZARD

A heat wave is a period of excessive heat, which can lead to illness and other stress to people with prolonged exposure to these conditions. High humidity, which often accompanies heat in Missouri, can make the effects of heat even more harmful. While heat-related illness and death can occur from exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. Consequently, the persistence of a heat wave increases the threat to public health. The National Weather Service (NWS) defines a heat wave as three consecutive days of temperatures of 90 degrees Fahrenheit (°F) and above. These high temperatures generally occur from June through September, but are most prevalent in the months of July and August. Missouri experiences about 40 days per year above 90 °F, based on a 30-year average compiled by the NWS from 1961 through 1990. July leads this statewide mean with 15 days above 90 °F, followed by August with an average of 12 days over 90 F. June and September average 6 days and 4 days, respectively, for temperatures above 90 °F. The 30-year climatic data is from NWS stations at Kansas City, Columbia, Springfield, and St. Louis. As these regional locations indicate, all of Missouri is subject to heat wave during the summer months.

Along with humans, animals also can be affected by high temperatures and humidity. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. The hotter the animal is, the more it will begin to shut down body processes not vital to its survival, such as milk production, reproduction, or muscle (meat) building.

Ambient temperature is not the only factor that should be considered when assessing the likely effects of heat. Relative humidity must also be considered, along with duration of exposure, wind, and activity. The NWS has stepped up its efforts to more effectively alert the general public and appropriate authorities to the hazards of heat waves–those prolonged episodes of excessive heat and humidity. The NWS has devised a Heat Index (HI), which is a combination of air temperature and relative humidity, and more accurately reflects the heat intensity.

The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when the relative humidity (RH) is added to the actual air temperature. The Heat Index Chart is shown on Figure E-1. As an example, if the air temperature is 96 °F (found on the left side of the table), and the relative humidity is 55% (found at the top of the table), the HI is 112 °F (the intersection of the 96° row and the 55% column). Because HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15 °F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

FIGURE E-1

Temperature (F) versus Relative Humidity (%)

°F	90%	80%	70%	60%	50%	40%	30%	20%	10%
65	65.6	64.7	63.8	62.8	61.9	60.9	60.	59.1	58.1
70	71.6	70.7	69.8	68.8	67.9	66.9	66.	65.1	64.1
75	79.7	76.7	75.8	74.8	73.9	72.9	72.	71.1	70.1
80	88.2	85.9	84.2	82.8	81.6	80.4	79.	77.4	76.1
85	101.4	97.	93.3	90.3	87.7	85.5	83.5	81.6	79.6
90	119.3	112	105.8	100.5	96.1	92.3	89.2	86.5	84.2
95	141.8	131.1	121.7	113.6	106.7	100.9	96.1	92.2	89.2
100	168.7	154.	140.9	129.5	119.6	111.2	104.2	98.7	94.4
105	200	180.7	163.4	148.1	134.7	123.2	113.6	105.8	100.
110	235.	211.2	189.1	169.4	151.9	136.8	124.1	113.7	105.8
115	275.3	245.4	218	193.3	171.3	152.1	135.8	122.3	111.9
120	319.1	283.1	250.	219.9	192.9	169.1	148.7	131.6	118.2

Risk Level	**Possible Heat Disorder:**
Caution	Fatigue possible with prolonged exposure and physical activity.
Extreme Caution	Sunstroke, heat cramps and heat exhaustion possible.
Danger	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
Extreme Danger	Heat stroke highly likely with continued exposure.

*Note: On the HI chart, the shaded zone above 105 °F corresponds to a level that may cause increasingly severe heat disorders with continued exposure or physical activity.

Heat waves are often a major contributing factor to power outages (brownouts, etc.), as the high temperatures result in a tremendous demand for electricity for cooling purposes. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Other related hazards include water shortages brought on by drought-like conditions and high demand. Local advisories, which list priorities for water use and rationing, are common during heat waves. Government authorities report that civil disturbances and riots are also more likely to occur during heat waves, as well as incidents of domestic violence and abuse.

III. HISTORICAL STATISTICS

Heat kills by taxing the human body beyond its abilities. In a normal year, approximately 175 Americans succumb to summer heat. In a 40-year period, 1936 through 1975, nearly 20,000 people died in the United States from the effects of heat and solar radiation. Over the past nine decades, the Missouri State Department of Health has compiled statistics for deaths from excessive heat. Figure E-2 in Section VII depicts the number of deaths in Missouri from 1911 to 2000. In 2001, it was reported that 47 Missourians died due to heat-related causes. In 2002, 24 persons died in Missouri due to heat. In United States, some

of the worst years for heat-related deaths occurred during the Great Depression, with 843 deaths in 1934, and 644 in 1936. The worst year in the past few decades was 1980, with 1,250 deaths from excessive heat.

IV. MEASURE OF PROBABILITY AND SEVERITY

Based on 30-year statistics from the NWS indicating the state's mean number of days above 90 °F, Missouri is vulnerable to heat waves ranging from high to moderate risk in July and August. The NWS has developed a Heat Index/Heat Disorder Chart that relates ranges of HI with specific disorders, particularly for people in higher risk groups (Table E-1).

TABLE E-1

Heat Index	Heat Disorder
130 °F or higher	Heat stroke or sunstroke likely with continued exposure
105 to 129 °F	Sunstroke, heat cramps, or heat exhaustion likely, and heat stroke possible with prolonged exposure or physical activity
90 to 104 ° F	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure or physical activity
80 to 89 °F	Fatigue possible with prolonged exposure or physical activity

Table E-2 shows the three response levels developed by the NWS, based on the Heat Index, to alert the public to the potential heat hazards:

TABLE E-2

Heat Index	Response Level
130 °F or higher	Warning
105 to 129 °F	Watch
90 to 104 °F	Advisory

Based on information from the Department of Health and Senior Services and the NWS, the State rates the probability of a heat wave as moderate and severity as moderate, but the probability could be upgraded to severe.

The Missouri Department of Health and Senior Services will announce a statewide hot weather health alert (Table E-3), when the conditions are as follows:

TABLE E-3

Type of Alert	Conditions of Alert
Hot Weather Health Alert	Heat indices of 105 °F in a large portion of the state are first reached (or predicted).
Hot Weather Health Warning	Heat indices have been 105 °F or more for 2 days in a large portion of the state; or weather forecasts call for continued heat stress conditions for at least 24 to 48 hours, over a large portion of the state.
Hot Weather Health Emergency	When extensive areas of the state meet the following criteria: (1) High sustained level of heat stress (HI 105 °F for 3 days), (2) Increased numbers of heat-related illnesses and deaths statewide, and (3) The NWS predicts hot, humid temperatures for the next several days for a large portion of the state.

V. IMPACT OF THE HAZARD

The severity of heat disorders tends to increase with age. Heat cramps in a 17-year-old can become heat exhaustion for someone in their forties, and may result in a fatal stroke for someone in their sixties. The following table lists conditions associated with heat, their symptoms and suggested first aid.

TABLE E-4

Heat Disorder	Symptoms	First Aid
Sunburn	Redness and pain. In severe cases, swelling of skin, blisters, fever, and headaches.	Apply ointment for mild cases if blisters appear. If breaking occurs, apply dry sterile dressing. Serious, extensive cases should be seen by physician.
Heat Cramps	Painful spasms possible usually in muscles of legs and abdomen. Heavy sweating.	Apply firm pressure on cramping muscles, or gentle massage to relive spasms. Give sips of water.
Heat Exhaustion	Heavy sweating and weakness; cold, pale and clammy skin. Pulse thready. Normal temperature possible. Fainting and vomiting.	Get victim out of sun. Lie down and loosen clothing. Apply cool wet cloths. Fan or move victim to air conditioned room. Give sips of water. If vomiting continues, seek immediate medical attention.

Heat Disorder	Symptoms	First Aid
Heat Stroke (or Sunstroke)	High body temperature (106 °F, or higher). Hot dry skin. Rapid and strong pulse. Possible unconsciousness.	Heat stroke is a severe medical emergency. Summon medical assistance or get the victim to a hospital immediately. Delay can be fatal. Move the victim to cooler environment. Reduce body temperature with cold bath or sponging. Use extreme caution. Remove clothing. Use fans and air conditioners. If temperature rises again, repeat process. Do not give fluids.

The following population groups are at a greater risk to becoming very sick from heat waves:

A. Those Vulnerable To Heat Stress Due To Physical Condition

1. Older people
2. Children
3. People overweight or underweight.

B. People With Limited Independence Due To Physical or Mental Disorders

1. People in institutional settings without air conditioning
2. People working in heat under stress (firefighters, police, emergency medical technicians)
3. People in urban environments where heat retention in asphalt, concrete and masonry is a factor (heat island effect)
4. People with low income who lack resources for air conditioning, transportation, medical care, etc.

C. Those With Increased Risk From Work or Leisure Activities

1. People who work outdoors (utility crews, construction crews, etc.)
2. Military personnel and trainees
3. Athletes.

D. Those More Difficult To Reach Through Normal Communications

1. People who live alone
2. People who are homeless
3. People who do not speak English
4. People who cannot read
5. People who are culturally, socially, or geographically isolated.

Even when a heat injury isn't fatal, it can be extremely serious and require lifelong monitoring of further exposure to heat. Besides mortality statistics due to heat, the Missouri Department of Health and Senior Services tracks heat-related injuries. Figure E-3 in Section VII shows heat-related illnesses in Missouri from 1991 through 2000.

As previously mentioned, animals can be adversely affected by heat stress. This poses a risk to farmers, ranchers, and the entire State of Missouri, which relies on agricultural revenue to keep the economy strong. Livestock producers cannot afford to ignore the effects of high temperatures on their herds. The following symptoms are signs of heat stress on livestock:

- Restlessness and crowding under shade or at water tanks/areas
- Open-mouthed breathing or panting and increased salivating
- Increased respiration rates
- Gasping and lethargic demeanor.

VI. SYNOPSIS

Many people do not realize how deadly a heat wave can be. In contrast to the visible, destructive, and violent nature of floods, hurricanes, and tornadoes, a heat wave is a "silent killer." Be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. To prevent heat-related illness, take the following precautions:

- Increase your fluid intake; drink more liquids than your thirst indicates.
- Drink nonalcoholic and caffeine-free liquids, such as water and juices.
- Wear lightweight, light colored, loose-fitting clothing.
- When unaccustomed to working or exercising in a hot environment, start slowly and pick up the pace gradually; rest frequently in a shady area.
- Spend time in an air-conditioned place; if not at home, then spend time in such public places as libraries, supermarkets, shopping malls, and movie theatres.
- Do not rely on fans as your primary cooling devices during a heat wave.
- Schedule outdoor activities carefully, preferably before noon or in the evening.
- When working in the heat, monitor the condition of your co-workers and have someone do the same for you.
- Monitor those at high risk, such as the elderly, infants, and children up to 4 years of age, someone who is overweight, or someone on medication.

- Ask your physician whether you are at particular risk because of medication.
- Do not leave infants, children, or pets unattended in a parked car or other hot environments.

Although fans are less inexpensive to operate, they may not be effective, and may even be harmful when temperatures are very high. As the air temperature rises, airflow is increasingly ineffective in cooling the body until finally, at temperatures above 100 °F (the exact number varies with the humidity), increasing air movement actually increases heat stress. More specifically, when the temperature of the air rises to about 100 °F, the fan may be delivering overheated air to the skin at a rate that exceeds the capacity of the body to get rid of this heat, even with sweating, and the net effect is to add heat rather than to cool the body. An air conditioner, if one is available, is a much better alternative. More information on heat-related illness is available through the Department of Health's web page at www.health.state.mo.us/ColdAndHeat/CandH.html.

VII. MAPS OR OTHER ATTACHMENTS

Attached are the Missouri Department of Health statistics for heat-related illnesses and deaths.

- Heat-Related Death Chart: Figure E-2
- Number of Heat-Related Illnesses in Missouri in 1991-2000: Figure E-3.

FIGURE E-2

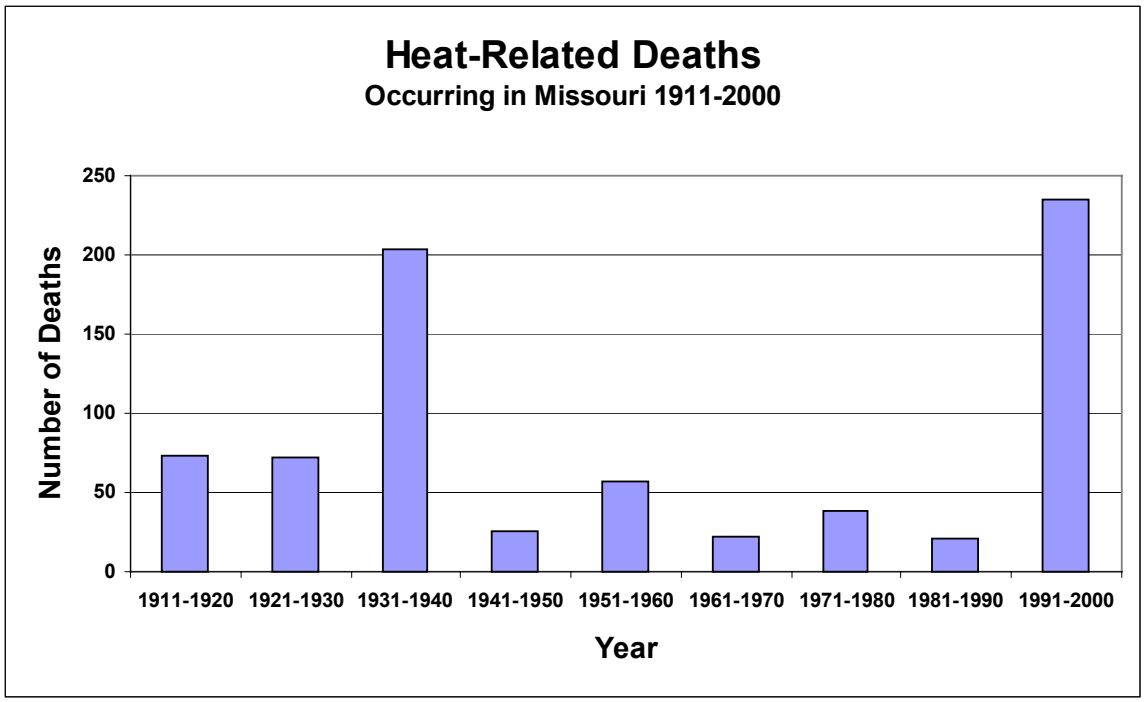
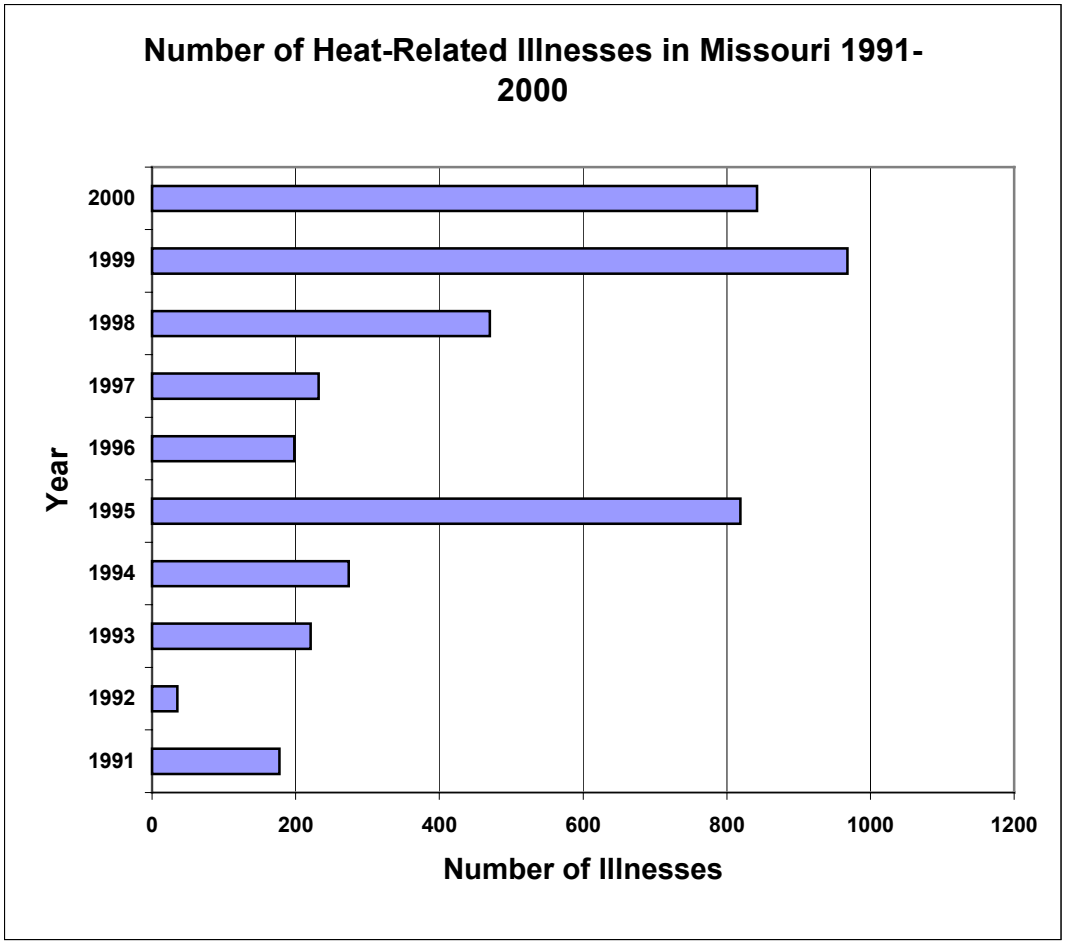

Heat-Related Deaths
Occurring in Missouri 1911-2000
Number of Deaths
250
200
150
100
50
0
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1971-1980
1981-1990
1991-2000
Year

FIGURE E-3


Number of Heat-Related Illnesses in Missouri 1991-2000
Year
2000
1999
1998
1997
1996
1995
1994
1993
1992
1991
0
200
400
600
800
1000
1200
Number of Illnesses

VIII. BIBLIOGRAPHY

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EARTHQUAKES

I. TYPE OF HAZARD

Earthquakes

II. DESCRIPTION OF HAZARD

Earthquakes can be defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts and sand blows.

The earth's crust is made up of gigantic plates, commonly referred to as tectonic plates. These plates form what is know as lithosphere and vary in thickness from 6 1/2 miles (beneath oceans) to 40 miles (beneath mountain ranges) with an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the athenosphere. The plates are in motion and where a plate joins another, they form boundaries. Where the plates are moving toward each other is called convergent plate boundary and when they are moving away from each other is called a divergent plate boundary. The San Andreas Fault in California is a horizontal motion boundary, where the Pacific plate is moving north while the North American plate is moving west. These movements release built up energy in the form of earthquakes, tremors and vulcanism (volcanoes). Fault lines such as the San Andreas come all the way to the surface and can be readily seen and identified. There are fault lines that do not come all the way to the surface, yet they can store and release energy when they adjust. Many of the faults in the Central United States can be characterized this way.

The subterranean faults were formed many millions of years ago on or near the surface of the earth. Subsequent to that time, these ancient faults subsided, while the areas adjacent were pushed up. As this fault zone (also known as a rift) lowered, sediments then filled in the lower areas. Under pressure, they hardened into limestones, sandstones, and shales - thus burying the rifts. With the pressures on the North Atlantic ridge affecting the eastern side of the North American plate and the movements along the San Andreas Fault by the Pacific plate, this pressure has reactivated the buried rift(s) in the Mississippi embayment. This particular rift system is now called the Reelfoot Rift.

There are eight earthquake source zones in the Central United States, two of which are located within the State of Missouri. Other zones, because of their close proximity also affect Missourians. These are the Wabash Valley Fault, Illinois Basin, and the Nemaha Uplift. The most active zone is the New Madrid Fault which runs from Northern Arkansas through Southeast Missouri and Western Tennessee and Kentucky to the Illinois side of the Ohio River Valley.

The Nemaha Uplift is of concern to Missourians because it runs parallel to the Missouri/Kansas border from Lincoln, Nebraska to Oklahoma City, Oklahoma. Its earthquakes are not as severe as the historic New Madrid fault zone, but there have been several earthquakes that have affected the Missouri side of the line.

III. HISTORICAL STATISTICS

During this decade, there was an earthquake of 3.1 Richter magnitude on March 31, 1993, close to the Cooper Nuclear Power Station in Brownville, Nebraska. It caused no damages, but was felt across the river near Rock Port, Missouri.

The most severe earthquakes occurred in the New Madrid fault zone during a period between December 16, 1811 and March 12, 1812 (see Figure 2). An engineer in Louisville, Kentucky counted over 1,850 shocks during this time, including three earthquakes of magnitude greater than 8.3 Richter magnitude. The shocks from these earthquakes could be easily felt as far away as Detroit, Michigan and Charleston, South Carolina. The area between the St. Francois River and Mississippi River south of New Madrid to Marked Tree, Arkansas showed numerous sand blows. A sand blow is a place where liquefacted alluvial soil has geysered out of the surface. Liquefaction is a phenomenon where the shaking of the ground separates the water from the soil holding it, causing the soil to behave like a dense liquid. The lack of water causes the soil to lose surface cohesion and molecules of sand from these blows to accumulate up to five feet in places. Liquefaction will cause land to lose its load bearing capacity.

Areas were uplifted as well as subsided (dropped) along the Mississippi River. Opposite New Madrid, the area around Tiptonville, Tennessee formed a dome (uplift of several yards). Immediately adjacent to the Tiptonville Dome, an area subsided to form a lake eighteen miles long and five miles wide. It is now known as Reelfoot Lake and is a tourist and recreation area.

Ground failure and landslides were apparent throughout the bluffs (Chickasaw Bluffs) alongside the Mississippi River in Kentucky and Tennessee. Many fissures were made throughout the region and one local observer recorded that the earth seemed to be rolling in waves of a few feet in height. These swells would burst, leaving wide and long fissures.

The damage to the area was so severe that Congress passed and President James Madison signed into law the first disaster relief act giving government lands in other territories to people wanting to move out of the area.

IV. MEASURE OF PROBABILITY AND SEVERITY

The Center for Earthquake Research and Information at the University of Memphis has computed conditional probabilities of a magnitude 6.0 Richter earthquake as being 40 percent to 63 percent through the year 2015. This probability increases to 86 to 97 percent in a 50-year period ending in 2035. With almost 12 1/2 million people living in the area, steps are being taken to reduce the hazard to the citizens and property in the area. The probability of an earthquake increases with each passing day, which makes it difficult to rate. **Based on the information from the Center of Earthquake Research and Information (University of Memphis), the probability is rated as moderate and the severity of an earthquake is rated as high.**

V. IMPACT OF THE HAZARD

The impact of earthquakes on Missouri can be significant. The three New Madrid Earthquakes of 1811-1812 can be construed as the largest that have happened in the North American continent. Although losses were limited because of the sparse population of the time, many uncounted Native American lives were lost and property was damaged to the point where resettlement became a national policy. In modern times, there have been several studies to indicate the need to mitigate for earthquakes as scholars estimate that the New Madrid Fault has the capability of generating Mercalli intensities of X (ten) in Southeast Missouri. The late Dr. Otto Nuttli of St. Louis University stated in his book, "The Effects of Earthquakes in the Central United States," that surface-wave magnitudes of 7.6 (Richter) create the largest possible earthquake that could occur anywhere along the New Madrid fault in the near future. He went on to say that there was a 7 percent probability of this occurring by the year 2000.

VI. SYNOPSIS

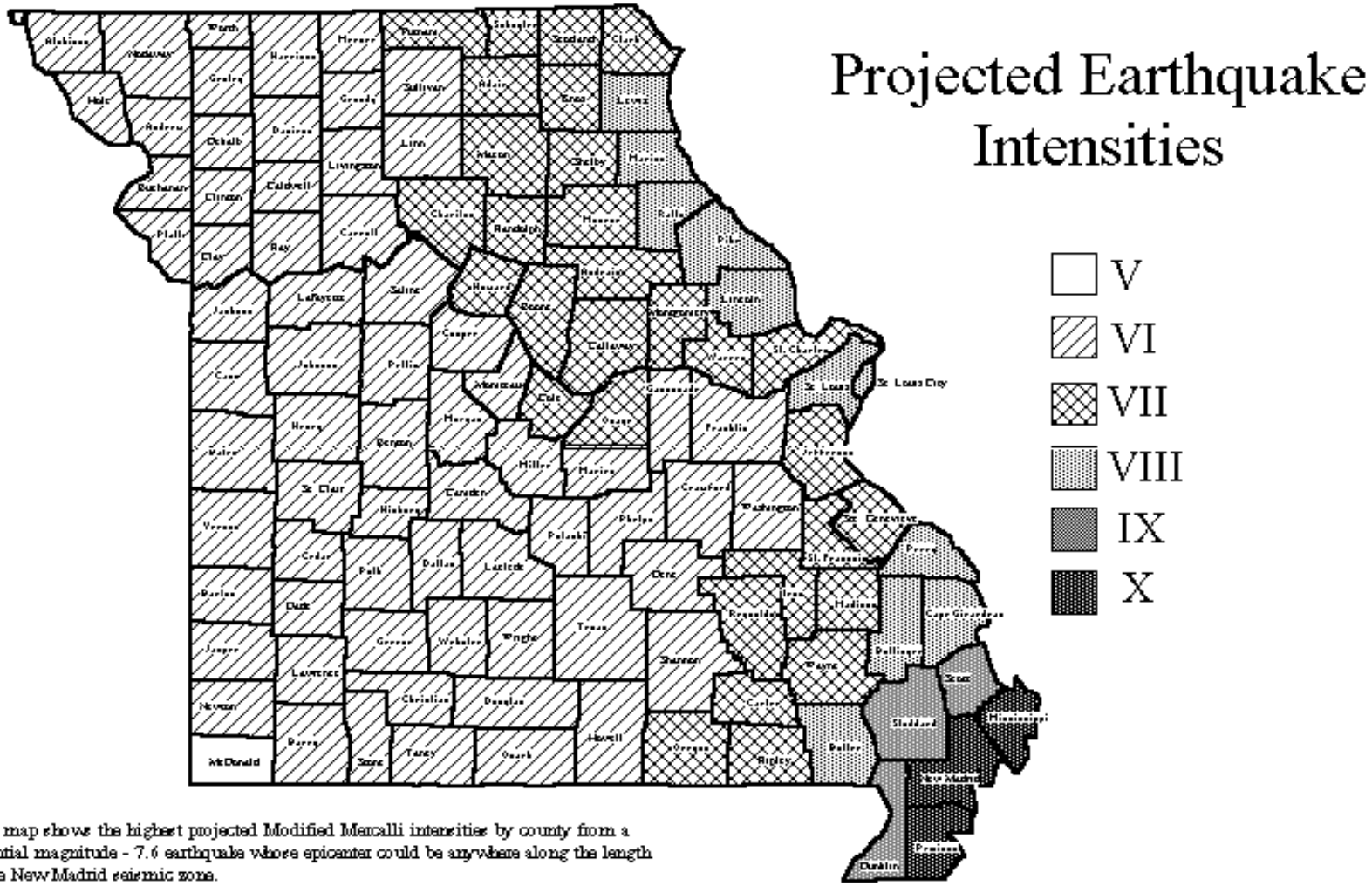
The chances of an earthquake increase with each day. The energy from the movement of the North American tectonic plate continues to build up along both the New Madrid and Nemaha Faults and their subsidiary fault systems. The state will have an earthquake. We don't know exactly where and we don't know exactly when, but we are overdue for a moderate earthquake. The citizens of Missouri and surrounding states will be affected by these earthquakes. There will be secondary effects from the earthquake, such as fire, building collapse, utility disruption, flooding, hazardous materials release, environmental impacts and economic disruptions/losses.

VII. MAPS OR OTHER ATTACHMENTS

The attached figures and tables show the estimated casualties and losses that one would expect from a 7.6 Richter magnitude earthquake along the New Madrid Fault.

Figure 1 **PROJECTED EARTHQUAKE INTENSITIES**

This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone. For a description of Projected Earthquake Intensities V through X , see following page.



This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude - 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

Table 1

DESCRIPTION OF PROJECTED INTENSITIES V THROUGH X

MODIFIED MERCALLI INTENSITY SCALE

V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.

VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.

VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.

VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.

IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.

X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

Table 2

Moderate/Large Earthquakes Central United States

DATE	LOCALITY	AREA MILES	INTENSITY	SOURCE ZONE
Dec. 16, 1811	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
Jan. 23, 1812	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
Feb. 7, 1812	New Madrid, Missouri	2,000,000	XII	New Madrid Fault
June 9, 1838	Southern Illinois	Widespread	VI	Illinois Basin
Jan. 4, 1843	Western Tennessee	40,000	VIII	New Madrid Fault
Unknown, 1860	Central Minnesota	Unknown	Unknown	Colorado Lineament
Aug. 17, 1865	Southeastern Missouri	24,000	VII	New Madrid Fault
April 24, 1867	Lawrence, Kansas	300,000	VII	Nemaha Uplift
June 18, 1875	Western Ohio	40,000	VII	Cincinnati Arch
Nov. 15, 1877	Eastern Nebraska	140,000	VII	Nemaha Uplift
Oct. 22, 1882	Arkansas - Texas	135,000	VI - VII	Ouchita-Wichita Fault
July 26, 1891	Illinois - Indiana	Unknown	VI	Wabash Valley Fault
Oct. 31, 1895	Charleston, Missouri	1,000,000	VIII	New Madrid Fault
May 26, 1909	Illinois	500,000	VII	Cincinnati Arch
April 9, 1917	Eastern Missouri	200,000	VI	St. Francois Uplift
March 8, 1937	Western Ohio	150,000	VII- VIII	Cincinnati Arch
April 9, 1952	Enid, Oklahoma	140,000	VII	Nemaha Uplift
Nov. 9, 1968	South Central Illinois	580,000	VII	Wabash Valley Fault
March 24, 1976	Marked Tree, Arkansas	115,000	V - VI	New Madrid Fault
July 27, 1980	North Central Kentucky	375,000	VII	Cincinnati Arch
Jan. 31, 1986	Anna, Ohio	440,000	VI	Cincinnati Arch
June 9, 1987	Lawrenceville, Illinois	125,000	V - VI	Wabash Valley Fault
Sept. 26, 1990	Chaffee, Missouri	140,000	IV - V	New Madrid Fault
May 3, 1991	Risco, Missouri	150,000	IV - V	New Madrid Fault
Dec. 7, 2001	Evansville, Indiana	24,000	IV-V	Wabash Valley Fault
May 4, 2001	Conway, Arkansas	36,000 est.	III-IV	Ohchita-Wichita Fault

Table 3

NEW MADRID SEISMIC ZONE
MAGNITUDE 7.6 EARTHQUAKE
ESTIMATED DEATHS AND SERIOUS INJURIES*

MMI	NO.	COUNTY	POPULATION	DEATHS % OF POP.	DEATHS # OF PEOPLE	SERIOUS INJURIES % OF POP.	SERIOUS INJURIES # OF PEOPLE
X	10	New Madrid	20,735	0.200%	41	1.000%	207
X	10	Mississippi	14,324	0.200%	29	1.000%	143
X	10	Pemiscot	21,749	0.200%	43	1.000%	217
IX	9	Dunklin	32,793	0.100%	33	0.500%	164
IX	9	Stoddard	28,849	0.100%	29	0.500%	144
IX	9	Scott	39,212	0.100%	39	0.500%	196
VIII	8	Butler	39,402	0.020%	8	0.100%	39
VIII	8	Bollinger	10,667	0.020%	2	0.100%	11
VIII	8	Cape Girardeau	62,454	0.020%	12	0.100%	62
VIII	8	Perry	16,818	0.020%	3	0.100%	17
VIII	8	St. Louis	997,067	0.020%	199	0.100%	997
VII	8	St. Louis City	392,160	0.020%	78	0.100%	392
VII	7	Ripley	12,449	0.002%	0	0.010%	1
VII	7	Oregon	9,502	0.002%	0	0.010%	1
VII	7	Carter	5,699	0.002%	0	0.010%	1
VII	7	Wayne	11,936	0.002%	0	0.010%	1
VII	7	Reynolds	6,723	0.002%	0	0.010%	1

MMI	NO.	COUNTY	POPULATION	DEATHS % OF POP.	DEATHS # OF PEOPLE	SERIOUS INJURIES % OF POP.	SERIOUS INJURIES # OF PEOPLE
VII	7	Iron	10,751	0.002%	0	0.010%	1
VII	7	Madison	11,228	0.002%	0	0.010%	1
VII	7	St. Francois	49,619	0.002%	1	0.010%	5
VII	7	Ste. Genevieve	16,042	0.002%	0	0.010%	2
VII	7	Washington	20,413	0.002%	0	0.010%	2
VII	7	Jefferson	174,663	0.002%	3	0.010%	17
		Other Counties	3,152,503		27		194

*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end of estimates in the CUSEIS study.

Table 4

NEW MADRID SEISMIC ZONE
MAGNITUDE 7.6 EARTHQUAKE
DAMAGE COSTS*

MMI	NO.	COUNTY	NUMBER OF BUILDINGS	BUILDINGS DAMAGED %	NUMBER OF BUILDINGS DAMAGED	$M COST OF BUILDINGS ($15K/BLDG)	$M COST OF INFRASTRUCTURE (1.5K x % DAMAGE/PERSON
X	10	New Madrid	8,294	70.00	5,806	$87	$22
X	10	Mississippi	5,730	70.00	4,011	$60	$15
X	10	Pemiscot	8,700	70.00	6,090	$91	$23
IX	9	Dunklin	13,117	50.00	6,559	$98	$25
IX	9	Stoddard	11,540	50.00	5,770	$87	$22
IX	9	Scott	15,685	50.00	7,842	$118	$29
VIII	8	Butler	15,761	30.00	4,728	$71	$18
VIII	8	Bollinger	4,267	30.00	1,280	$19	$5
VIII	8	Cape Girardeau	24,982	30.00	7,494	$112	$28
VIII	8	Perry	6,727	30.00	2,018	$30	$8
VIII	8	St. Louis	398,827	30.00	119,648	$1,795	$449
VIII	8	St. Louis City	156,864	30.00	47,059	$706	$176
VII	7	Ripley	4,980	5.00	249	$4	$1
VII	7	Oregon	3,801	5.00	190	$3	$1
VII	7	Carter	2,280	5.00	114	$2	$0

MMI	NO.	COUNTY	NUMBER OF BUILDINGS (0.4 x POP.)	BUILDINGS DAMAGED %	NUMBER OF BUILDINGS DAMAGED	$M COST OF BUILDINGS ($15K/BLDG)	$M COST OF INFRASTRUCTURE (1.5K x % DAMAGE/PERSON
VII	7	Wayne	4,774	5.00	239	$4	$1
VII	7	Reynolds	2,689	5.00	134	$2	$1
VII	7	Iron	4,300	5.00	215	$3	$1
VII	7	Madison	4,491	5.00	225	$3	$1
VII	7	St. Francois	19,848	5.00	992	$15	$4
VII	7	Ste. Genevieve	6,417	5.00	321	$5	$1
VII	7	Washington	8,165	5.00	408	$6	$2
VII	7	Jefferson	69,865	5.00	3,493	$52	$13
		Other Counties	1,261,001		24,506	$368	$92

*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end of estimates in the CUSEIS study.

EKAUQHTRAE67EDUTINGAM
*shaeD
0
5
10
15
20
14
29
34
33
29
39
8
2
21
3
91
87
0
0
0
0
0
0
1
0
0
3

Figure 2

Figure 3

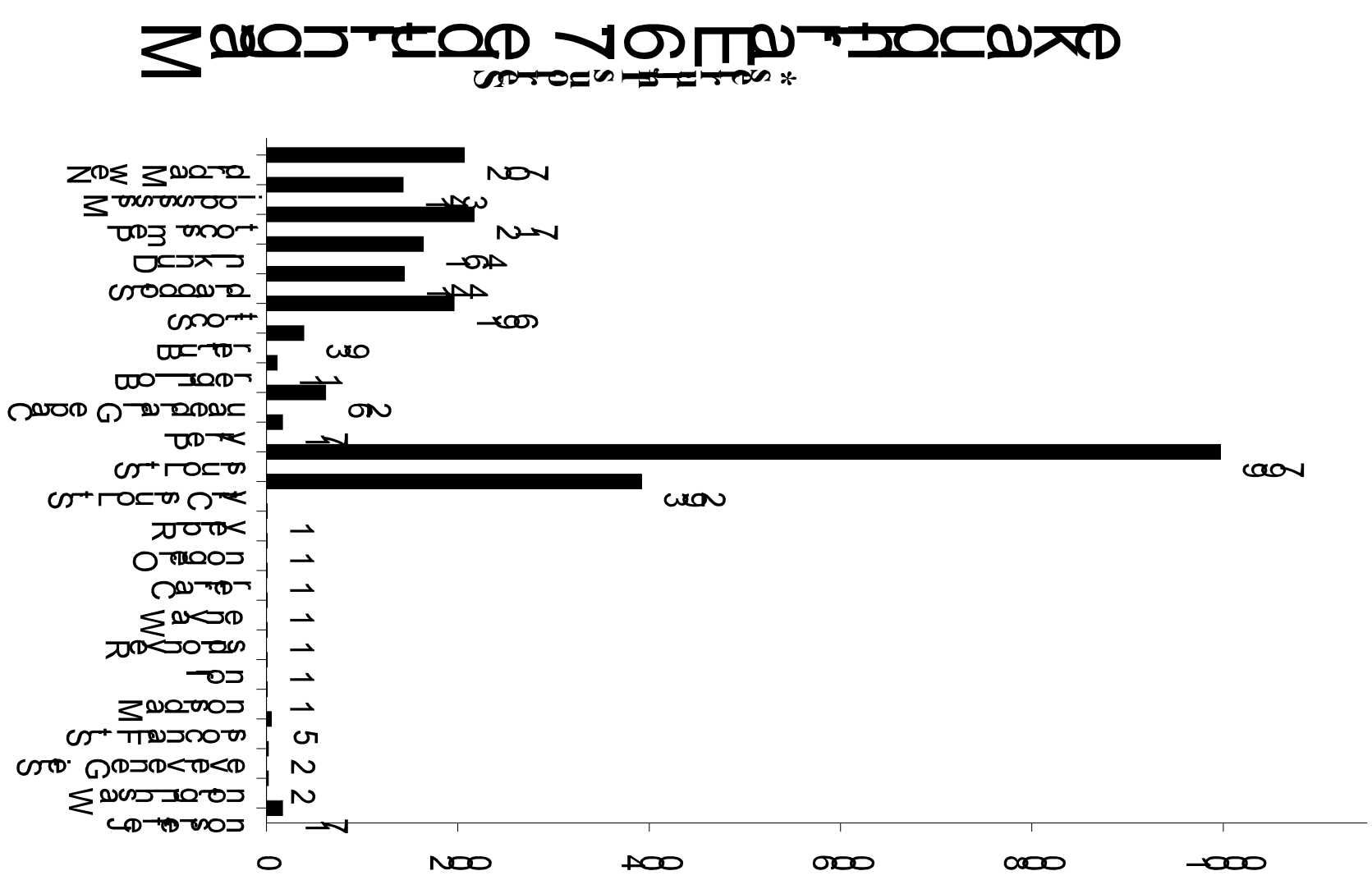


Figure 4

Motorcycle Operator Fatalities by Helmet Use*
Motorcycle Operator Fatalities by Helmet Use*
Helmet Use
Non-Use
Unknown
0
500
1000
1500
2000
2500
Connecticut
Delaware
Dist. of Columbia
Hawaii
Iowa
Kentucky
Maine
Massachusetts
Michigan
Minnesota
New Hampshire
New Jersey
New York
North Carolina
Oregon
Pennsylvania
Rhode Island
South Carolina
Texas
Vermont
Virginia
Washington
Wisconsin

Figure 5

Motorcycle Operator Fatalities*
Motorcycle Operator Fatalities per 100,000 Registered Motorcycles
0
500
1000
1500
2000
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Florida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming

*Estimates are from figures derived from CUSEIS (Central United States Earthquake Intensity Scale) published by the Center for Earthquake Studies, Southeast Missouri State University, Cape Girardeau, Missouri. The figures used are based on the 1990 Census data, utilizing the low end range of estimates in the CUSEIS study.

DAM FAILURES

I. TYPE OF HAZARD

Dam Failures

II. DESCRIPTION OF HAZARD

Over the years dam failures have injured or killed thousands of people, and caused billions of dollars of property damage in the United States. Among the most catastrophic were the failures of the Teton Dam in Idaho in 1976, which killed 14 people and caused more than $1 billion in damage, and the Kelly-Barnes Dam in Georgia which left 39 dead and $30 million in property damage. In the past few years, there were over 200 documented dam failures nationwide, that caused four deaths and millions in property damage and repair costs. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredricktown in 1977, and a near failure in Franklin County in 1979. More recently, a severe rainstorm and flash flooding in October 1998 compromised about a dozen small, unregulated dams in the Kansas City area. Overall, many of Missouri's smaller dams are becoming a greater hazard as they continue to age and deteriorate. While hundreds of them need to be rehabilitated, lack of available funding and often questions of ownership loom as obstacles difficult to overcome.

A **dam** is defined by the National Dam Safety Act as an artificial barrier which impounds or diverts water and: (1) is more than 6 feet high and stores 50 acre feet or more, or (2) is 25 feet or more high and stores more than 15 acre feet. Based on this definition, there are over 80,000 dams in the United States. Over 95% are non-federal, with most being owned by state governments, municipalities, watershed districts, industries, lake associations, land developers, and private citizens. Dam owners have primary responsibility for the safe design, operation and maintenance of their dams. They also have responsibility for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials. The State has ultimate responsibility for public safety, and many states regulate construction, modification, maintenance, and operation of dams, and also ensure a dam safety program.

Dams can fail for many reasons. The most common are:

1. **Piping:** internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam.

2. **Erosion:** inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection.

3. **Structural Failure:** caused by an earthquake, slope instability or faulty construction.

These three types of failures are often interrelated. For example, erosion, either on the surface or internal, may weaken the dam and lead to structural failure. Whereas, a structural failure may shorten the seepage path and lead to a piping failure. Observable defects that provide good evidence of potential dam failures are illustrated in Section VII of this annex.

Dam construction varies widely throughout the state. A majority of dams are of earthen construction. Missouri's mining industry has produced numerous tailing dams for the surface disposal of mine waste. These dams are made from mining material deposited in slurry form in an impoundment. Other types of earthen dams are reinforced with a core of concrete and/or asphalt. The largest dams in the state are built of reinforced concrete, and are used for hydroelectric power.

III. HISTORICAL STATISTICS

Missouri had some 4,100 recorded dams in 1995, the largest number of man-made dams of any state in the United States. The topography of the state allows lakes to be built easily and inexpensively, which accounts for the high number. Despite such a large number, only about 620 Missouri dams (about 20 per cent) fall under state regulations, while another 85 dams are federally controlled. A non-federal dam can be anything from a large farm pond (e.g. MFA Research Farm Lake Dam in Saline County which is 20 feet high and holds back 60 acre feet of water) to Bagnell Dam which created the Lake of the Ozarks. The great majority of non-federal dams are privately owned structures that were built either for agricultural or recreational use. Missouri also has some 600 dams which were built as small watershed projects under Public Law-566 (Watershed Protection and Flood Prevention Act of 1953). These dams serve many functions, including flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Many are nearing the end of their 50-year lifespan and are in bad need of repair. Another group of older dams in the state were originally built by railroads as holding ponds for water to be used in steam locomotives. Many of these are now used as drinking water reservoirs by the towns and cities close to where they were built.

Within the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program within the Division of Geology and Land Survey. The objective is to insure that dams are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. Under that law, a dam must be 35 feet or higher to be state regulated. These dams are surveyed by state inspectors at least every five years. However, the majority of Missouri dams are less than 35 feet high and thus, not regulated. While the State has for many years encouraged dam owners to do owner inspections for those dams not under Chapter 236 RSMO, the condition of many of these dams continues to deteriorate.

IV. MEASURE OF PROBABILITY AND SEVERITY

Dams are generally classified in three categories which identify the potential hazard to life and property should a failure occur:

1. **High Hazard** - If the dam were to fail, lives would be lost and extensive property damage could result.

2. **Moderate Hazard** - Failure could possibly result in the loss of life and appreciable property damage.

3. **Low Hazard** - Failure results in only minimal property damage.

Status of Missouri Privately-Owned Dams

In the 1980 Missouri Dam Survey, 681 dams, or 21% of the dams surveyed had a high hazard potential, while 754 dams, or 23% of the dams surveyed had a moderate hazard potential. Another 1,818 dams, or 56% of the dams surveyed had a low hazard potential. However, many of Missouri's unregulated, private dams have gone unchecked for decades, according to Jim Alexander, chief engineer for DNR's dam safety program. Dams that don't get regular attention can erode over the years, or be damaged by floods, he notes. "There are accidents out there waiting to happen." Some of the potential hazardous dams are five miles from a downstream city. If a dam fails, the owner is still responsible for damage, Alexender says, "but there's no legal handle on them to maintain them." Information collected from the Corps of Engineers 1980 National Inventory of Dams is outdated, and owners of unregulated dams may have changed. Concern is mounting even for some of the state's regulated dams; particularly the Silver Creek Dam east of Rockaway Beach in Taney County, where the owner is unknown. Erosion is just eating away at the 40-foot high dam, and the runoff creates silt deposits along the shore of Lake Taneycomo. One end of the dam is a barren clay bank that could give way during a heavy rainstorm, Alexander says. DNR's plans were to obtain money through the State Legislature to repair the dam, and have the Attorney General's Office seek reimbursement from the owner when that person is identified. DNR is also proposing changes in state law that would lower the height limit for regulated dams to 25 feet on those holding back 50 acres or more of water. However, such a measure was not expected to go before the Legislature before 2001.

Missouri's Small Watershed Projects With Dams

In 1954, Missouri built its first small watershed dam, and today has over 600 built under PL-566. These dams vary in size and perform multiple functions, including flood and erosion control. Many have a designed life of 50 years, and time has taken its toll. According to a 1999 report, about 25 of these dams are more than 40 years old, and most will need major rehabilitation soon. More than 130 dams are 30-39 years old, while 182 of them are 20-29 years old. (See pie chart, figure 3, in Section VII.)

The Iowa Watershed Task Force published a series of case studies in 1999 on aging watershed dams. Their Missouri case study on the Tabo Creek Watershed Project in Lafayette County best illustrates the range of problems. The Tabo Creek project was authorized in 1960, with the first dam constructed in 1961. Since then, 64 grade-stabilization dams have been installed. Many of these dams now face the same problems that plague older dams in other watersheds approaching the end of their 50-year design life. They include deteriorating pipes and sediment filling the reservoirs. The most common problem is decaying pipes, since 44 of the dams were installed with corrugated metal pipes. One of the most visible problems is the lakes filling with sediment. The Lafayette County Soil and Water Conversation District is responsible for operation and maintenance, and performs annual inspections on each structure. However, the local sponsors don't have the funds needed to rehabilitate all the structures, which would cost an estimated $6 million, the case study notes. To date, no dams built under the Small Watershed Program anywhere in the U.S. have failed that resulted in loss of life or property. However, some have exhibited significant problems that were corrected before a catastrophic failure or tragedy has occurred. The chances of such occurrences will undoubtedly increase as the dams get older.

U.S. Army Corps of Engineers Operated Reservoir Dams in Missouri

The U.S. Army Corps of Engineers operates and maintains nearly a dozen large federally regulated, reservoir dams in Missouri through its Kansas City, St. Louis and Little Rock Districts. Extensive care is taken by the Corps in the design, construction and operation of their dams, and as a result, the Corps record for dam safety is considered excellent. Nevertheless, dam failures elsewhere in the country raise the possibility that any one of these facilities could still fail. The threat of an earthquake in some areas of the state, the possibility of sabotage or terrorist activities, or other natural/technological event are among the potential risk factors that could cause such a structure to fail.

For its regulated dams, the Corps Kansas City District began a program in1999 to revise their Contingency Plans for seven district dams which they operate in Missouri. The plans were republished as emergency action plans, to provide an updated emergency notification/ points of contact list in the event of a dam failure; increased communications with local emergency management officials; and a more simplified format for clarity. The Corps K.C. District worked jointly with the State Emergency Management Agency (SEMA), the National Weather Service, and local officials, including the county sheriff and emergency management coordinator in the affected counties (24 hours below stream). The plans were updated for Pomme de Terre Dam (Hickory and Benton counties); Blue Springs Dam (Jackson County); Longview Dam (Jackson County); Smithville Dam (Clay and Platte counties); Long Branch Dam (Macon and Randolph counties); Stockton Dam (Cedar and St. Clair counties); and Truman Dam (Benton and Morgan counties). Two other counties, Schuyler and Putnam, were included in an updated plan for the Corps' Rathbun Dam in Iowa.

The Corps St. Louis District maintains flood emergency plans for its Clarence Cannon Dam/Mark Twain Lake project, with the plan covering Ralls, Monroe, Pike and Shelby counties; and Lake Wappapello Dam for Wayne, Butler, Stoddard and Dunklin counties. The Corps Little Rock District has similar plans for Table Rock Dam, Taney and Ozark counties; and for Clearwater Dam, Wayne, Butler and Reynolds counties. A map showing the location of the Corps' Missouri reservoir dams by county, and adjacent counties that could be impacted (emergency notification), is shown as figure 4.

Missouri's percentage of high hazard dams in the DNR inventory puts the State at about the national average for that category. However, the probability of dam failure increases as many of the smaller and privately-owned dams continue to deteriorate over the years without the benefit of further regulation or improvements. **Based on this information, the State rates the overall probability as moderate and the severity as moderate.**

V. IMPACT OF THE HAZARD

When a dam fails, the pent-up water can be suddenly unleashed and have catastrophic effects on life and property downstream. Homes, bridges and roads can be demolished in minutes. The failure of the Buffalo Creek Dam in 1972 in West Virginia killed 125 people. Should the Silver Creek Dam in Taney County fail, for example, the ensuing flood would likely take out a section of Missouri Highway 176, endanger other structures, and dump tons of silt into the lake. There have been at least 26 recorded dam failures in 20 Missouri counties since the turn of the century. Fortunately, only one drowning has been associated with a dam failure in the state, and there has been little consequence to property.

Residents near a high or moderate hazard dam should become familiar with the dam's emergency

action plans. Emergency plans written for dams include procedures for notification and coordination with local law enforcement and other governmental agencies, information on the potential inundation area, plans for warning and evacuation, and procedures for making emergency repairs.

VI. SYNOPSIS

Dam breaks are caused most often by failure of the structure itself. However, flooding is the most common hazard interacting with dam failure. Prolonged rains and flooding can saturate earthen dams, for example, producing much the same breaching effect as that which occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded by the excess water. A large slide may develop in either the upstream or downstream slope of the embankment, and threaten to release the impounded water. Complete structural collapse can occur, especially as a result of an earthquake, or severe tremors.

Actual dam failure can not only result in loss of life, but also considerable loss of capital investment, loss of income, and property damage. Loss of the reservoir itself can cause hardship for those dependent on it for their livelihood or water supply. Loss of the reservoir itself can also upset the ecological balance of the area as well.

VII. MAPS OR OTHER ATTACHMENTS

Illustrations: Figure 1, Observable Defects; Table 1, Dams In Missouri By Purpose; Table 2, and Figure 2, Dams In Missouri By County; Figure 3, Aging Small Watershed Dams (Missouri and national average); Figure 4, Missouri Counties With Corps of Engineers Reservoir Dams.

Figure 1

OBSERVABLE DEFECTS

Table 1	**Dams in Missouri by Purpose**	
	Number	**Percent**
Fire and Farm Ponds	381	10.8%
Flood Control	285	8.0%
Hydroelectric	8	0.2%
Irrigation	296	8.4%
Navigation	7	0.2%
Recreation	1,826	51.6%
Tailings and Others	487	13.8%
Water Supply	243	6.9%
Undetermined	8	0.1%

Table 2

COUNTY	NO. OF DAMS	COUNTY	NO. OF DAMS
Adair	27	Daviess	16
Andrew	21	DeKalb	57
Atchison	11	Dent	34
Audrain	85	Douglas	5
Barry	1	Dunklin	2
Barton	31	Franklin	134
Bates	23	Gasconade	76
Benton	25	Gentry	19
Bollinger	27	Greene	17
Boone	123	Grundy	36
Buchanan	29	Harrison	113
Butler	29	Henry	39
Caldwell	18	Hickory	7
Callaway	106	Holt	18
Camden	20	Howard	30
Cape Girardeau	28	Howell	24
Carroll	46	Iron	37
Carter	12	Jackson	74
Cass	67	Jasper	14
Cedar	11	Jefferson	146
Chariton	24	Johnson	91
Christian	3	Knox	21
Clark	33	Laclede	18
Clay	35	Lafayette	188
Clinton	25	Lawrence	7
Cole	30	Lewis	67
Cooper	22	Lincoln	67
Crawford	74	Linn	17
Dade	11	Livingston	58
Dallas	4	McDonald	3

COUNTY	NO. OF DAMS	COUNTY	NO. OF DAMS
Macon	22	Ray	38
Madison	23	Reynolds	22
Maries	27	Ripley	23
Marion	21	St. Charles	106
Mercer	25	St. Clair	15
Miller	14	St. Francois	60
Mississippi	3	Ste. Genevieve	49
Moniteau	19	St. Louis	38
Monroe	25	St. Louis City	2
Montgomery	83	Saline	23
Morgan	11	Schuyler	15
New Madrid	1	Scotland	22
Newton	15	Scott	16
Nodaway	52	Shannon	8
Oregon	9	Shelby	23
Osage	21	Stoddard	26
Ozark	7	Stone	1
Pemiscot	3	Sullivan	32
Perry	32	Taney	7
Pettis	27	Texas	6
Phelps	29	Vernon	43
Pike	46	Warren	114
Platte	24	Washington	116
Polk	13	Wayne	33
Pulaski	13	Webster	19
Putnam	10	Worth	35
Ralls	29	Wright	10
Randolph	44		

Figure 2

NUMBER OF DAMS BY COUNTY

Source: Inventory of Dams, Department of Natural Resources, Division of Dam Safety

Figure 3

Our Aging Dams

Survey of Small Watershed Dams

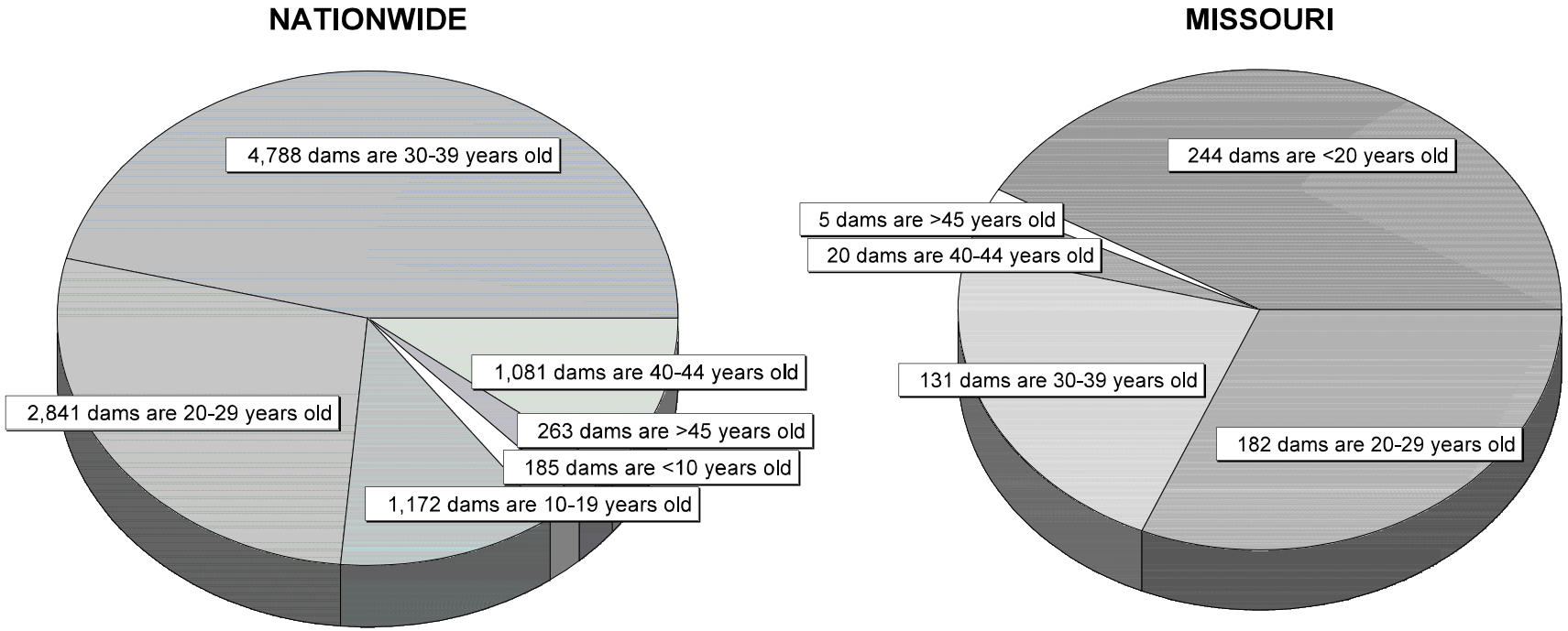


Figure 4

MISSOURI COUNTIES WITH CORPS OF ENGINEERS RESERVOIR DAMS

In the event of a dam failure, emergency warning/notification procedures are provided in both Corps of Engineers flood emergency plans and local county emergency operations plans to alert local officials in the threatened areas. Emergency notification includes the county in which the dam is located, and adjacent/nearby counties below stream which may also be impacted. The Corps maintains such emergency plans for each individual dam, and copies are kept on file with the State Emergency Management Agency.

ANNEX H

UTILITIES
(INTERRUPTIONS AND SYSTEM FAILURES)

I. TYPE OF HAZARD

Utilities—Interruptions and System Failures

II. DESCRIPTION OF HAZARD

Utility interruptions and failures may involve electrical power, natural gas, public water and communications systems. All of these systems or a combination of these utility systems exist virtually throughout the state. Many utilities are localized and serve only one community, while other utilities serve a regional area. Utilities are often dispersed over a wide area, and many have facilities located throughout their service area. For example, many electric companies have multiple generating facilities, which can redistribute power via transmission lines as they are connected to load stations. Therefore, power can be redistributed, if needed, so that power is lost to as limited an area as possible. Many water companies have some type of back-up systems, such as water impoundments, other deep wells or hook-up arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications and natural gas utilities. Utility systems exist everywhere and are subject to damage from digging, fire, traffic accidents, and severe weather, including flooding and other day-to-day events. Many utilities utilize emergency batteries or generators to provide back-up power for high priority equipment.

III. HISTORICAL STATISTICS

Because utilities exist everywhere in the state, damage to utilities may occur frequently. This may be due to a backhoe cutting a buried line, an accident involving a motor vehicle, a flood or other severe weather. Many of these interruptions or failures go unreported to the Public Service Commission (PSC), and no definitive reporting system exists. Therefore, limited statistical information is available.

During the flood of 1993, telecommunications companies proved their adaptability by using cellular service to replace wire line service in areas where service could not be restored in a timely manner. One Local Exchange Company (LEC) utilized a trailer with cellular pay phones where the land lines were interrupted. Another company temporarily replaced analog subscriber carrier service with site-based cellular service. Short-haul portable microwave was also utilized to replace copper lines lost during the flood.

On January 30, 2002, a severe ice storm struck portions of western and northern Missouri, leaving devastation and darkened homes and businesses. Many news articles referred to this ice storm as the worst in Missouri's history. During the ice storm, ice accumulated on any object that was at or below freezing, and the weight of the ice broke utility poles, conductors, tree limbs and other objects that could not withstand the weight of the ice. Ice accumulations over an inch were reported in many areas. Many tree branches could not withstand the added weight of the ice and fell to the ground, striking whatever was in their path. Cars, homes, streets, properties, and electric power facilities were recipients of the falling trees and limbs. When the ice began to melt, the falling ice caused additional outages. Some electric customers experienced outages more than once during that period, as power was restored but

interrupted again by falling limbs. At the peak of outages, over 400,000 customers were without power. Within three days, most of these customers were returned to service, but many customers in more heavily damaged areas were without power for over a week. Utilities affected by the ice storm quickly mobilized all of their available crews and sought outside assistance. Work crews from 16 different states came to western Missouri in an effort to rapidly restore power to as many customers as possible. For additional information about severe winter weather in Missouri, see Section of this Hazard Analysis Plan.

IV. MEASURE OF PROBABILITY AND SEVERITY

Because utilities exist throughout the state and are vulnerable to interruptions or failures, there is a high probability that this hazard may occur at anytime or anyplace throughout the state. In many cases, these are small isolated events, well within the capabilities of the local utility to address. Therefore, the degree of severity of these day-to-day events may be considered low. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. Recent regulatory, planning and structural initiatives designed to minimize interruptions and failures are listed below.

V. IMPACT OF THE HAZARD

Utility outages and interruptions can be very localized, or region-wide. Their greatest impact is generally upon the very young or elderly, who can be expected to have greater health risks associated with resultant loss of heating/cooling systems and with the loss of medical equipment that requires a power source. Loss of communications can also adversely affect the provision of emergency services, making it difficult to contact the services for emergency assistance. In addition, utility outages can cause significant problems within the financial community, should there be a long-term loss of their data communications.

A. Communications

During 1990, the Telecommunications Staff of the PSC requested that LECs submit plans for disaster recovery. Every LEC in the state submitted a plan that lists practices and procedures for any kind of disasters whether natural or man-made. The PSC has recommended to the telecommunication industry that in the event of an emergency, the various companies and emergency agencies should coordinate a single point of contact for emergency situations.

In order to mitigate the damage of earthquakes or other disasters, the LECs added bracing to all their central offices for their switching equipment and batteries. Since earthquakes or other disasters may affect electrical service, which is essential for operations, many companies have obtained on-site generators or made contingency arrangements to acquire them in a disaster. For additional information regarding earthquakes in Missouri, see to Section F of this Hazard Analysis Plan. Such generators would be needed prior to exhaustion of emergency battery supplies, which may last about 8 hours. During the flood of 1993, one LEC provided emergency power to a central office, which was isolated by flood waters. This was accomplished by driving a flat bed truck through the water with a diesel generator mounted on the bed. The generator was fueled by boat.

Vulnerability of buried telecommunication cables has always been a problem. Cables may be subject to accidental or intentional cuts. However, legislation and mitigation procedures have been taken to prevent such events. Senate Bill Numbers 214 and 264 provided for the existence of a company called “One Call”, which locates and marks buried utilities. Currently, most LECs in the state have their facilities on record with the “One Call” agency. Anyone planning any

subsurface digging, drilling, or plowing of any kind is advised and encouraged to use the “One Call” service. Additional steps to prevent cutting of buried telecommunication cables include clearly marking cable routes with above ground pedestals and poles, as well as patrolling the routes by vehicle and air. In addition to these precautions, most companies are presently building fiber rings for the fiber optic routes, to protect continuity of service in the event of an accidental cut.

Since floods pose a threat to telephone service, most companies with buried cables in floodplains are replacing conventional telephone pedestals with flood resistant telephone pedestals, which protect the cables during floods of short duration. For additional information on flooding in Missouri, see to Section B of this Hazard Analysis Plan.

B. Electrical Service

Electrical utilities in Missouri prepare for disasters and power outages by developing written plans to follow when abnormal events cause extensive outages to customers. Power outages caused by severe weather have prompted the creation of tree trimming plans to ensure above ground power lines are free of potential limbs that could fall on power lines and cause interruptions of power if knocked down. In addition, ongoing review of emergency plans and training for such events have been implemented. During the 2002 ice storm that struck western and northern Missouri, many customers were unable to contact affected utilities by telephone because there were not enough utility representatives to respond to all customer calls. Therefore, an automated system was developed to allow customers to input information to the computer that will automatically generate work orders for service calls. The PSC also advised utility companies to provide feedback to customers that their outage was recorded, to convey assurance that their outage report has been received.

C. Natural Gas

All natural gas system operators in the state operate under the jurisdiction of the PSC. These operators must comply with the Commission's Pipeline Safety Regulations, which include emergency response procedures to pipeline emergencies and natural disasters. Natural gas system operators have plans on file with the PSC. Part of these plans include indexes of utilities and their locations in the state.

In 1989, House Bill 938 provided the Commission with additional legal power to enforce the Pipeline Safety Regulations. In 1990, due in part to the Iben Browning earthquake projection, all utilities were mandated by the Commission to develop natural disaster plans (to include potential impacts of earthquakes) and file the plans with the Commission. The Commission also developed its own plan to respond to a disaster causing an interruption or failure of a utility service. The Iben Browning earthquake projection created a new awareness for the necessity for such disaster response and recovery plans. Several natural gas companies have since stored emergency equipment and survival rations in protected locations. This also resulted in a new demand for excess flow and motion sensing valves on natural gas service lines. Operators also reviewed, updated or increased their mutual aid agreements with other utilities and contractors.

In 1990, Senate Bill numbers 214 and 264 required all owners and operators of underground pipeline facilities to participate in the Missouri "One Call" notification center. These bills altered the original Chapter 319 Damage Prevention Act and added a penalty clause. This participation provides for the location of underground pipelines after notification by the excavator and before any excavation work begins.

VI. SYNOPSIS

Utility companies are generally well prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-states utilities is the greatest concern to the integrity and operability of Missouri's utilities. Planning, regulation, mitigation and mutual aid are all just a few tools available to reduce, speed recovery and prevent utility interruptions and failures.

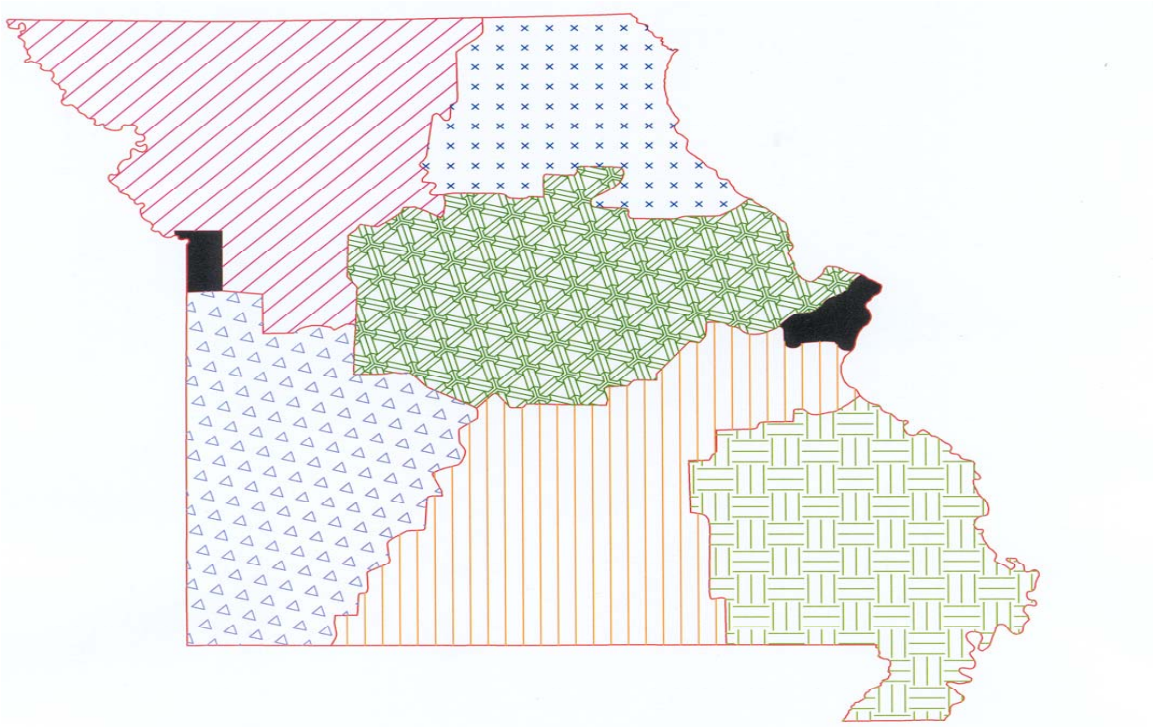
VII. MAPS OR OTHER ATTACHMENTS

An earthquake map showing all pipelines and electrical transmission lines is on file with the State Emergency Management Agency's, Earthquake Section. Attachments to this section include the following figures:

- Electrical Cooperatives in Missouri: Figure H-1
- Major Interstate Natural Gas Pipelines in Missouri: Figure H-2.

FIGURE H-1

ELECTRICAL COOPERATIVES IN MISSOURI



N.W. Electric Power Cooperative, Inc.

Transmits power to: Atchison-Holt, Farmers', Grundy, North Central Missouri, Platte-Clay, United and West Central electric cooperatives.

Northeast Missouri Electric Power Cooperative

Transmits power to: Lewis County, Macon, Missouri Rural, Ralls County and Tri-County electric cooperatives in Missouri as well as three Iowa co-ops.

Central Electric Power Cooperative

Transmits power to: Boone, Callaway, Central Missouri, Co-Mo, Consolidated, Cuivre River, Howard and Three Rivers electric cooperatives.

KAMO Power

Transmits power to: Barry, Barton County, New-Mac, Osage Valley, Ozark, Sac Osage, Southwest and White River Valley electric cooperative in Missouri as well as several cooperatives in Oklahoma and Arkansas.

Sho-Me Power Electric Cooperative

Transmits power to: Crawford , Gascosade, Howell-Oregon, Intercounty, Laciede, Se-Ma-No, Southwest, Webster and White River Valley electric cooperatives.

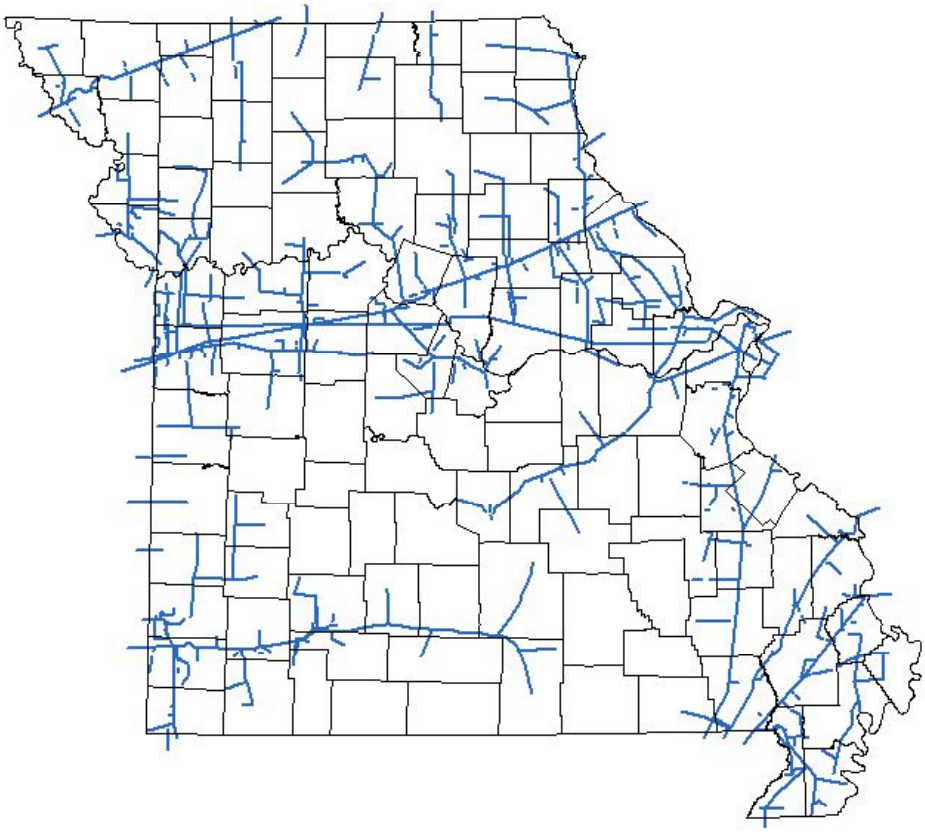
M & A Electric Power Cooperative

Transmits power to: Black River, Ozark Border, Pemiscot-Dunklin and SEMO electric cooperatives.

Not Included in Missouri Electric Power Cooperatives

FIGURE H-2

MISSOURI PIPELINES



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ANNEX I

FIRES
(STRUCTURAL, URBAN, AND WILD)

I. TYPE OF HAZARD

Fires (Structural, Urban, and Wild)

II. DESCRIPTION OF HAZARD

Fires can range in scope to include structural, urban, and wild fires. For the purpose of this analysis, structural and urban fires are considered in one category, with wild fires, including forest, prairie, and grassland locations, considered separately.

Structural fires are a major problem that can affect any area of the state. The Missouri Division of Fire Safety (MDFS) indicates that approximately 80 percent of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression. Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance. The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multi-story building in a large city.

Because fires can occur anywhere in the state, the MDFS has actively promoted the enactment of a statewide fire code. Although no statewide code has been enacted to date, successful legislative efforts to improve fire safety have included the following:

1. Fire, Safety, Health, and Sanitation Inspections of Child Care Facilities (RSM 210.252)

2. Boiler and Pressure Vessel Safety Act (RSM 650.200)

3. Elevator Safety Act (RSM 701.350).

Fires impact many aspects of society in terms of economic, social, and other indirect costs. According to the MDFS, the most costly crime in the state is arson. This should be a great concern to citizens, law enforcement, the judicial system, and the fire service sector. Fires caused by arson impact citizens through higher insurance premiums, lost jobs, loss of lives, injuries, and property loss. Primary duties of the Missouri State Fire Marshal include the investigation of fires, explosions, and any related occurrences. The investigative staff is responsible for investigating any fire requested by fire service and law enforcement within the state. This also includes explosions, bombings, and all other related offenses.

Presently, the MDFS investigative staff includes 1 deputy chief, 2 regional chiefs, and 18 field investigators. This staff must cover all 114 counties and is dedicated to assisting any local or state agency and conducting quality investigations. The investigators are trained in several fields of expertise, including arson for fraud, explosives recognition, and post-blast training. The Division uses four canines, including three specifically trained in accelerant detection and one in explosives detection.

The MDFS Training Unit develops and oversees the training curriculum being provided regionally for state certification of fire fighters, fire investigators, fire inspectors, and fire service instructors. Although fire fighter certification is not mandatory in Missouri, currently over 15,000 individuals are certified by the MDFS.

Also, the MDFS has initiated a statewide mutual aid system. This system enhances the ability of rural (volunteer) or city (paid) fire departments to handle major fires within their jurisdictions. To compliment the statewide mutual aid system, an incident management system (IMS) overhead team concept has been developed throughout the state. This should assist the rural and city fire departments in the management of a major fire disaster. Figure I-1 shows the Fire/Rescue Mutual Aid Regions in Missouri.

The MDFS is responsible for the enforcement of fireworks laws throughout Missouri. In addition to conducting inspections of any facilities involved with fireworks, approximately 1,350 permits are issued yearly to manufacturers, wholesalers, and retailers of fireworks. Illegal fireworks are a concern because they can be dangerous, causing loss of lives, severe injuries, and property damage.

The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately-owned and state-owned forests and grasslands from the destructive effects of wildfires. To accomplish this task, eight forestry districts have been established in the state to assist with the quick suppression of fires (see Figure I-2). The Forestry Division works closely with Volunteer Fire Departments and Federal partners to assist with fire suppression activities. Currently, more than 900 rural fire departments have mutual aid agreements with the Forestry Division to obtain assistance in wildfire protection if needed; a cooperative agreement with the Mark Twain National Forest is renewed annually. Figure I-3 illustrates the 12 Mark Twain National Forests across Missouri.

Forest and grassland fires can occur any day throughout the year. Each year, an average of about 3,700 wildfires burn more than 55,000 acres of forest and grassland in Missouri. Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions. Spring in Missouri is noted for its low humidity and high winds. These conditions, together with below-normal precipitation and high temperatures, result in extremely high fire danger. In addition, due to the continued lack of moisture throughout many areas of the state, conditions are likely to increase the risk of wildfires. Drought conditions can also hamper fire-fighting efforts, as decreasing water supplies may not provide for adequate fire fighting suppression. Spring is when many rural residents burn their garden spots, brush piles, and other areas. Many landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, with the possibility of extremely high fire dangers and the increased opportunities for fires, the spring months are the most dangerous for wildfires. The second most critical period of the year is fall. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.

III. HISTORICAL STATISTICS

Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the state. The frequency of structural fires depends on a wide range of factors. These factors include, but are not limited to population or building density, building use, lack of fire codes, lack of enforcement when fire codes exist, fire safety practices (or lack thereof) by building occupants, lack of adequately equipped fire departments, and criminal intent related to arson.

Data on the frequency of structural fires is included in the Missouri Fire Incident Reporting System Statistics (MFIRS) data provided by the MDFS. However, according to the MDFS, only 384 of approximately 900 fire departments have reported data used to compile the MFIRS. For this reason, definitive conclusions are not possible; however, fire departments, law enforcement offices and other agencies spend considerable manpower and funding to respond to and investigate structural fires.

The Forest Division of the MDC is responsible for protecting the privately-owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry districts have been established. At the present time, the forestry districts afford intensive fire protection to approximately one-half of the state, or about 16 million acres. Within these districts, fairly accurate forest and grassland fire statistics are available from the MDC. In a typical year, approximately 3,700 wildfires occur. In 2002, 2,376 wildfires occurred in Missouri, burning 54,397 acres. Debris burning (fires resulting from land clearing, burning trash, range, stubble, right-of-way, logging slash, etc.) is the major cause of forest and grass fires in Missouri. Incendiary fires (fires willfully set by anyone on property not owned or controlled by him, and without the consent of the owner) continue to rank second in the number of wildfires that occur each year.

Table I-1 below lists the number and causes of forest and grassland fires in 2002 and the acres burned. Table I-2 shows the number of fires and acreage burned by forest and grassland fires yearly from 1993 to 2002.

TABLE I-1

2002 STATEWIDE FIRES BY CAUSE

Cause	Number	Acres	% Number	% Acres
Lightening	15	52	0.6 %	0.1 %
Campfire	15	113	0.6 %	0.2 %
Smoking	94	2,181	4.0 %	4.0 %
Debris	1,446	22,801	60.9 %	41.9 %
Arson	349	20,096	14.7 %	36.9 %
Equipment	78	688	3.3 %	1.3 %
Railroad	9	26	0.4 %	0.0 %
Children	19	203	0.8 %	0.4 %
Miscellaneous	237	3,191	10.0 %	5.9 %
No Report	114	5,046	4.8 %	9.3 %
TOTAL	2,376	54,397	100 %	100 %

In north and west-central Missouri, the MDC has limited firefighting forces. Forestry Division personnel, however, provide training and limited federal excess equipment to the many volunteer rural fire departments. See Figure I-2 for a map of the MDC forestry districts.

TABLE I-2

STATEWIDE FIRES AND ACRES BURNED

Year	Fires	Acres
1993	2,994	31,952
1994	2,748	51,896
1995	2,910	48,907
1996	3,793	88,933
1997	2,487	29,557
1998	1,112	10,415
1999	1,348	18,270
2000	4,910	132,718
2001	2,972	41,092
2002	2,376	54,397

IV. MEASURE OF PROBABILITY AND SEVERITY

Even with the limited data in the MFIRS statistics, the probability of structural fires is quite high. Total monetary loss in 2002 according to the MFIRS, was over $75 million. In addition, there were 40 fire-related deaths in Missouri during 2002. Therefore, severity could be considered moderate.

The probability of wildfires (forest, prairie, and grassland) is considered moderate overall, but may increase to high during certain periods such as spring or late fall, or under conditions of excessive heat, dryness, or drought. The severity would be considered low to moderate.

V. IMPACT OF THE HAZARD

Structural and urban fires are a daily occurrence throughout the state. Approximately 100 fatalities occur annually, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system.

VI. SYNOPSIS

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

VII. MAPS OR OTHER ATTACHMENTS

- Fire/Rescue Mutual Aid Regions: Figure I-1
- Missouri Department of Conservation Forestry Districts: Figure I-2
- Mark Twain National Forests: Figure I-3.

FIGURE I-1

MISSOURI FIRE AND MUTUAL AID REGIONS

FIGURE I-2

MISSOURI DEPARTMENT OF CONSERVATION FORESTRY DISTRICTS

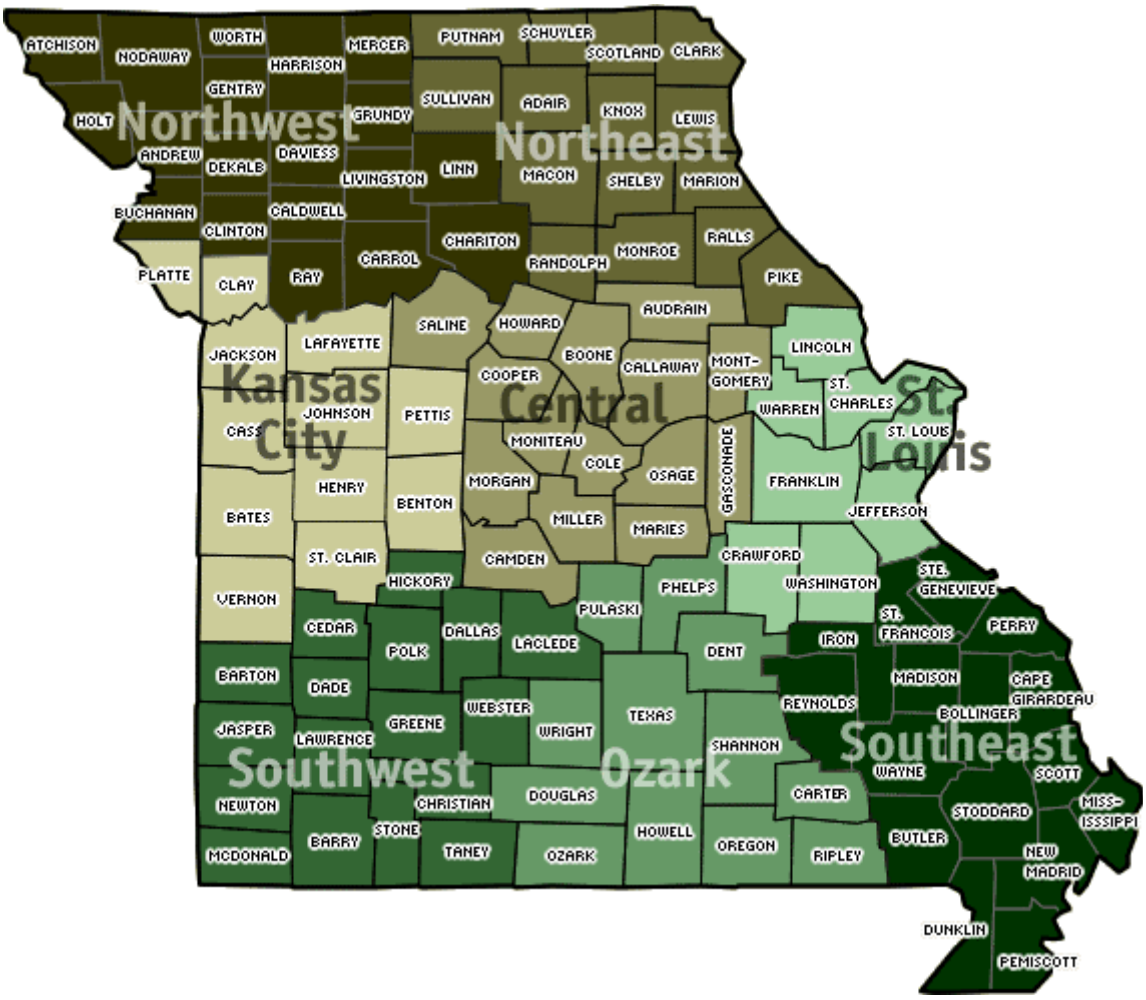
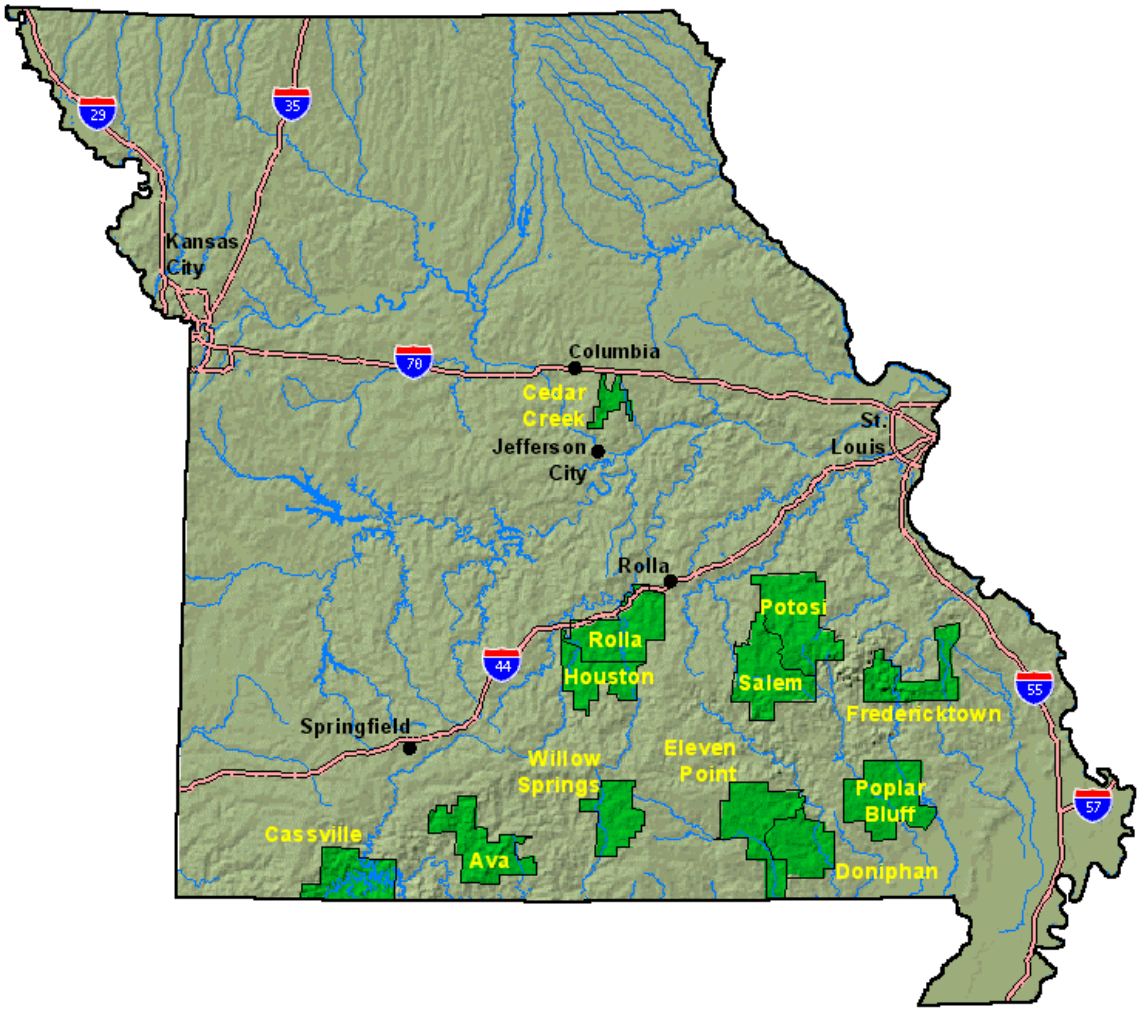


FIGURE I-3

MARK TWAIN NATIONAL FORESTS



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NUCLEAR POWER PLANTS
(FIXED NUCLEAR FACILITIES)

I. TYPE OF HAZARD

Nuclear Power Plants (Fixed Nuclear Facilities)

II. DESCRIPTION OF HAZARD

There are presently four fixed nuclear facilities or reactors that under extreme circumstances and conditions could pose a threat to the general public of Missouri. These four reactors fall into two categories: Research Reactors and Commercial Nuclear Power Reactors. The first category, Research Reactors, only represent a hazard to personnel or the public on site of the facility. Therefore, they are not included in state radiological plans involving off-site emergency preparedness. In the second category, Commercial Nuclear Power Reactors, a worst case scenario where a significant release of radioactive material has occurred could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food sources out to a 50-mile radius.

Releases from nuclear plant sites are dependent on the nature of the accident type, reactor design, and meteorological conditions during the release. The Nuclear Regulatory Commission (NRC) and Federal Emergency Management Agency (FEMA) have developed regulatory guidances that both the state and utility must meet to ensure the health and safety of the general population within the 10-mile Emergency Planning Zone (EPZ). There are four classes of Emergency Action Levels that are used for early notification of the severity of the incident, with clear instructions for off-site actions of emergency organizations within the EPZ. The four emergency classifications listed in progression of severity are:

Notification of Unusual Event

This classification describes unusual events that are in process or have occurred which indicate a potential degradation of the level of safety of the plant. No releases of radioactive material requiring off-site response or monitoring are expected unless further degradation of safety systems occur.

Alert

This classification describes unusual events that are in process or have occurred which indicate a potential degradation of the level of safety of the plant. Any releases are expected to be limited to small fractions of the Environmental Protection Agency (EPA) Protective Action Guideline (PAG) exposure levels.

Site Area Emergency

This classification level describes events in process or having occurred which involve actual or likely major failures of the plant functions needed for protection of the public. Any releases are not expected to exceed EPA PAG exposure levels except near the site boundary.

General Emergency

This classification describes an event in process or having occurred which involves actual or imminent substantial core degradation or melting, with the potential for loss of containment integrity. Releases can reasonably be expected to exceed the EPA PAG exposure levels off-site for more than the immediate site area.

III. HISTORICAL STATISTICS

Research Reactors

There are two research reactors located in the State of Missouri: the University of Missouri-Rolla Reactor (UMRR) and the University of Missouri Research Reactor (MURR). The maximum hypothetical accident from either research reactor would only place at risk personnel working at the facilities or the public within the site boundary of the respective facilities. Both research reactors have Emergency Plans approved by the Nuclear Regulatory Commission (NRC) that conform with regulatory requirements in 10 CFR 50, Appendix E, following the guidance provided by Revision I to NRC Regulatory Guide 2.6, Emergency Planning for Research and Test Reactors, March 1982, and ANSI/ANS-15.16, Emergency Planning for Research and Test Research Reactors, November 29, 1981.

UMRR

UMRR is a water moderated pool type reactor licensed to operate at 200 KW. The UMRR is used for training and research purposes. Because the reactor is mainly used for training, it is not operated for long periods of time. The reactor is located on the east side of the Rolla campus near 14th Street and Pine Street in Rolla, Missouri. Due to the low power of licensing (200 KW), prevailing standards and guidelines do not require the establishing of an emergency planning zone. Therefore, no classification higher than a Site Area Emergency has been included in their emergency plans. The UMRR has been in operation since December 1961 and has never had an incident that would be considered an emergency action level.

MURR

MURR is a 10 MW pressurized water moderated pool type reactor with a containment building. The MURR is utilized for research, training, and services to the four campuses of the University of Missouri system, other universities, government agencies, and private industry as well. The reactor is located on a 550-acre tract of land south of the University of Missouri-Columbia campus on Providence Road. The MURR has an emergency planning zone of 100-meter radius from the exhaust stack. There have been no credible accidents identified for the MURR facility that would result in exceeding the classification of Notification of Unusual Events. As a result, no classification higher than a Site Area Emergency is included in the emergency plan for the MURR. The MURR has been in operation since October 1967. The reactor averages 8,060 hours of operation per year (155 hours per week) at peak flux due to the service work that it performs. The MURR has never had an incident during its history of operation that would be considered an emergency action level.

Commercial Nuclear Power Reactors

There are two commercial nuclear power reactors which could have an impact on the health and safety of Missouri citizens. These reactors are the Callaway Nuclear Plant and the Cooper Nuclear Station. Both of the plants are used for electrical power generation. Both utilities have Emergency Plans that conform to NUREG-0654, FEMA-REP-1 Rev.1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants. The utilities and the state are required annually to demonstrate various elements of preparedness in their plans through radiological emergency drills evaluated by inspectors representing the Federal Emergency Management Agency (FEMA) and the NRC.

Callaway Nuclear Plant

The Callaway Plant consists of one unit with a pressurized water reactor capable of providing 1150 MW of electricity. The plant is located in Callaway County, Missouri and is owned and operated by Union Electric, St. Louis. It is located ten miles southwest of Fulton, 25 miles northeast of Jefferson City, 5 miles north of the Missouri River, and 80 miles west of St. Louis. The population within the 2.5-mile radius of the plant is low (approximately 30 residents). The 10-mile radius would include approximately 4,500 people. Taking into account political as well as physical boundaries, the 10-mile radius has been adjusted to include the City of Fulton (population 10,000). Thus, the population within the Plume Exposure Pathway is approximately 16,000. The plant site consists of 7,200 acres of land at the site, 6,800 of which are administered by the Missouri Department of Conservation as the Reform Conservation Area. Under this program, part of the area continues to be farmed, with income from farming providing funds for wildlife management and public recreation activities. Land within a 5-mile radius of the plant site is rural, consisting of 60 percent forest, 20 percent farm/crop land, and 20 percent pasture. **The Callaway Plant has declared eight Unusual Events since it came on line in 1984. To date the last declared event was on May 18, 1989.**

Cooper Nuclear Station

The Cooper Nuclear Station is a direct cycle boiling water type reactor with a net electrical generating capacity of 800,000 Kilowatts. The facility is owned and operated by the Nebraska Public Power District of Lincoln, Nebraska. The plant is located on the Nebraska side of the Missouri River, approximately 7 miles southwest of Rock Port, Missouri in Brownville, Nebraska. The Emergency Planning Zone within the Missouri side of the river is predominantly rural land, with the exception of the towns of Rock Port, population 1,511, Phelps City, population 39, Langdon, population 32, and Watson, population 117. Atchison County is primarily affected by the EPZ and is intersected by several major highways. Highways included are I-29, U.S. Highway 136, U.S. Highway 275, and Missouri Highway 111. The total population at risk in Atchison County, should there be a radiological incident, is: within 2 miles, approximately 15 people; within five miles, approximately 246 people; and within ten miles, approximately 2,660 people. **The Cooper Nuclear Station has declared 22 Unusual Events since 1974 when it began operation. To date the last declared event occurred on November 19, 1996.**

IV. MEASURE OF PROBABILITY AND SEVERITY

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the state can range in severity from insignificant to a high degree of radioactive contamination within the 2-10 mile area surrounding the facility. The most crucial concerns during a severe incident would be the safe evacuation of the public and controlled access to the areas affected by a release or radioactive materials. In the aftermath, the main concerns are: the extent of property needed to be decontaminated; identifying any contaminated food sources; and the amount of time it would take to reach acceptable exposure rates to allow safe reentry of the public. Historically, due to their safe operation records, there is no indication that any of the fixed nuclear facilities affecting the state represent a high risk. **The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster related to a power plant as very low (a probability of one in one million per plant operating year).** The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown which could be expected to occur once in 20,000 years of reactor operation. The report also stated that a meltdown would likely cause less than one fatality or injury. **This low hazard rating is due to all of the added safety engineered instrumentation used to monitor and shut down nuclear plant systems prior to any severe damage occurring.**

V. IMPACT OF THE HAZARD

An incident at a nuclear power plant resulting in a General Emergency and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State of Missouri have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the state and local jurisdictions, and regularly scheduled drills and exercises which are evaluated by the Federal Emergency Management Agency. Extensive planning has been given to implementation of the emergency response plan for both the state and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public informaiton in the form of brochures distributed to residents within the Emergency Preparedness Zone. These programs are essential to the protection of the general public.

VI. SYNOPSIS

Nuclear reactors in the U.S. have been designed to survive natural disasters such as tornadoes and earthquakes without damage to critical systems. Considerable emphasis is placed on multiple-level governmental reviews of the design, construction and operation of each nuclear power plant. These safety reviews begin prior to construction and continue throughout the operating life of the plant. Radiological Planning and Preparedness programs that are monitored by state and federal agencies are in place to ensure that the safety of the general public is a priority within the

Emergency Planning Zone. In addition, nuclear power plant history in the state and on a national level give no indication that a serious accident involving a nuclear power plant will ever occur.

VII. MAPS OR OTHER ATTACHMENTS

Attachment 1 - EPZ map of Callaway Nuclear Power Plant (page J-6)

Attachment 2 - EPZ map of Cooper County Nuclear Plant (page J-7)

HAZARDOUS MATERIALS

I. TYPE OF HAZARD

Hazardous Materials

II. DESCRIPTION OF HAZARD

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment or property. Incidents involving these substances, such as toxic chemicals, fuels, nuclear waste, and other radiological materials, for example, are covered in one principal category of Hazardous Materials.

With hazardous materials, we need to consider two different kinds of incidents i.e., fixed facility and transportation accidents. With a fixed facility, the hazards are pre-identified and the facility is required by law to have risk management planning done and provide a copy of this plan to the Local Emergency Planning Commission (LEPC), and local fire departments. They must also fill out a Missouri Tier II form and file it with the Missouri Emergency Response Commission (MERC) in the State Emergency Management Agency (SEMA). A list of all facilities that filed a Tier II form is on file with SEMA, Hazardous Materials Program Manager. For specific site plans, each county LEPC by law is required to maintain a copy of these plans.

The exact location of a hazardous material accident is not possible to predict. The close proximity of railroad, highway, waterway and industry to densely populated areas, schools and businesses could put a large number of residents in danger. In addition, essential service facilities such as police and fire stations, hospitals, nursing homes and schools that are in proximity to major highway or railroads are also in jeopardy from a hazardous material incident.

Federal Highway Administration statistics indicate that one out of ten motor vehicles is engaged in the transportation of hazardous materials. The Corps of Engineers indicates that over 9,000 tons of petroleum products and over 200,000 tons of chemicals and related products are shipped by way of the Missouri River between Omaha and Kansas City by river barge.

Nationwide, over four billion tons of hazardous materials are shipped each year by various transportation modes. There are no less than 20 flights each day out of Lambert Airport carrying nuclear medicines, and Tri-State Motor Transit Company of Joplin has over 25 shipments of high explosives each week.

Missouri becomes even more involved because of its highway system and geographical location. With Interstate highways such as I-29, I-35, I-44, I-55 and I-70, Missouri offers the best road routes for commercial carriers traversing the continent. Even arterial United States highways in Missouri, such as U.S. 71, 13, 63, 54, etc., are maintained to such high standards as to provide more favorable traveling conditions than are found in other central states. Also, the locations of nuclear facilities in relation to mines and fuel processing plants cause shipments of radioactive products and wastes to cross Missouri.

Missouri will be at the crossroads for rail and trucking nuclear waste transportation to the Yucca Mountain, Nevada test site.

Truck shipments alone will affect 25 different states, 266 counties and two Indian Reservations. This will be a potentially large waste shipping campaign from as many as 19 nuclear reactors through corridor states to Nevada.

The railroads in Missouri transport voluminous amounts and kinds of materials on their 6,351 miles of rails that transverse the state. Though individual cars may be placarded to reveal contents such as hazardous materials, only estimates can be obtained concerning volumes of such materials because just interstate traffic can be counted or measured. Interstate shipments are accounted for only when they originate or terminate.

Increased use and movement of materials across the country has created serious problems for emergency services personnel. There are many factors which can transfer a simple transportation accident into an incident of potential hazard to high numbers of people. Following is a potpourri of such factors:

- There are over 14,000 different chemicals being shipped by various transportation modes.

- Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds even though 900 pounds could wipe out a small town.

- Few emergency response organizations (state, city, or county) have any training for handling peacetime radiological problems, and none have adequate training.

- Lack of intelligence reports regarding activity of possible terrorists.

Other scenarios involve nuclear terrorism and faulty re-entry of nuclear powered satellites reaching the earth (such as COSMOS 954 in 1978 and SKYLAB in 1980). However, all other things considered, transportation of radioactive materials presents the most probable scenario for a radiological incident.

The Department of Energy has begun shipping by train about twenty-one million cubic feet of low specific activity (LSA) radioactive waste from the decommissioned Fernald site near Cincinnati, Ohio to a repository near Salt Lake City, Utah. The trains will be composed of forty-three (43) gondola cars each, with a frequency of about one (1) every nine (9) days for <u>five (5) years.</u>

These trains cross Missouri through St. Louis and Kansas City on the Union Pacific tracks (about the same route used by the Three Mile Island trains). They will be easy for SEMA to monitor, if desired, since the UP tracks run about five hundred (500) yards south of the SEMA headquarters building.

Eventually, the federal government will overcome all political barriers and finalize development of long-term repositories for spent fuel and other high-level radioactive wastes, and for

transuranics (known as TRUwaste); probably at Yucca Mountain, Nevada and Carlsbad, New Mexico, respectively. When those shipments begin, speculations suggest numbers as high as thirty-six hundred (3600) shipments per year depending upon several variables.

Dispensing with speculation, we can look at factual numbers obtained from three (3) corporations in Missouri, Mallinckrodt Medical in Maryland Heights (St. Louis County), Tri-State Motor Transit in Joplin, and ABB-Combustion Engineering in Hematite (Jefferson County).

Mallinckrodt Medical is one of the largest manufacturer of radiopharmaceuticals in the world and average of forty-five hundred (4500) packages per week, 2000 to 2500 by air.

Tri-State is one of the largest single private carrier of radioactive materials in the world. In 1994, they carried no less than one hundred sixty-seven (167) shipments through Missouri.

ABB-Combustion Engineering operates a nuclear fuel fabrication facility in Jefferson County about seven (7) miles west of Festus/Crystal City. They receive about twenty (20) shipments of uranium hexaflouride (UF^6), a mildly radioactive but highly corrosive form of uranium. ABB-CE processes this material into ceramic pellet assemble fuel bundles for nuclear power reactors. They ship out about five hundred (500) assemblies, or about forty (40) truck loads per year.

Missouri truly is a hub of transportation. The Interstate corridors of I-44, I-70 and I-55 are the most commonly used for truck transport. U.S. Highway 36 crosses the northern counties while U.S. 60 crosses the southern counties. U.S. Highways 71, 13, 65 and 63 are well-traveled North-South arterial.

Although there are many railroads crossing Missouri at all points of the compass, the Union Pacific route between St. Louis and Kansas City is the most used for large radioactive material shipments. The switching yards at St. Louis and Kansas City process more transcontinental trains than any other yards.

During any radiological emergency, whether resulting from the detonation of a weapon or the misuse of industrial or medical radioisotopes, local officials and emergency responders will require support in the detection, monitoring and analysis of radiological data for decision-making.

In 1990, ATSDR (Agency for Toxic Substances and Disease Registry) began funding selected stated health departments to participate in the Hazardous Substances Emergency Events Surveillance (HSEES) system. Five states were initially funded. Missouri was added in the fiscal year 1994 and became the twelfth participating state Minnesota and Mississippi were added to the HSEES system in fiscal year 1995. The goal of this surveillance project is to reduce injuries and deaths to first responders, employees and the general public from hazardous substance emergencies.

A hazardous substance release is entered into the HSEES system if it meets the following criteria:

1. An uncontrolled or illegal release or threatened release of one or more hazardous substances;

2. The substances that are actually released or threatened to be released include **ALL** hazardous substances except petroleum products; and

3. The quantity of the hazardous substances which are released, or are threatened to be released, need (or would need) to be removed, cleaned up, or neutralized according to federal, state or local law; or

4. Only a threatened release of hazardous substances exists, but this threat leads to an action, such as an evacuation that can potentially impact on the health of employees, responders or the general public. This action makes the event eligible for inclusion into the surveillance system even though the hazardous substances are not released.

Data collection for the Missouri HSEES system began October 1, 1993. Reports of hazardous substances releases in Missouri come from a variety of sources, including the Missouri Department of Natural Resources (MDNR), the Missouri State Highway Patrol, Missouri Division of Fire Safety, Missouri Occupational Fatality Assessment & Control Evaluation (MOFACE) program, State Emergency Management Agency and media reports. The MDNR's Environmental Services Program is the primary notification source for Missouri's HSEES program.

Based on these reports, the HSEES coordinator contacts company officials, police/fire department personnel, victims, etc., to obtain the maximum amount of information about the event. Then, an incident report form is completed. The form includes the following information:

1. Where and when the event occurred, including whether the event took place at a fixed facility or during the transportation of the substance;

2. Weather conditions, time of day and day of the week when the event occurred;

3. Substance(s) and quantity released or substance(s) threaten to be released;

4. Data related to possible exposure, such as proximity to residential areas; the primary use of nearby land (e.g., commercial, industrial, agricultural or residential); the number of people living within one-quarter, one-half and one mile of the event; and how many people were actually home when the release took place; and

5. Deaths and injuries that resulted from the event, including who was injured (e.g., employee, general public, responder), the number and severity of injuries and steps that may have been taken to prevent deaths or injuries (e.g., type of personal protective equipment that the

injured used, and whether they were a responder, employee, member of the general public or a student.

III. HISTORICAL STATISTICS

The Missouri Department of Natural Resources' Environmental Services Program maintains Environmental Emergency Response (EER) reports. All environmental emergencies are to be reported, 24 hours a day, to (573) 634-2436. A total of 1,638 reports were received beginning October 1, 1995 through September 30, 1996. Of these, 835 (51%) were petroleum related. There were 226 (14%) potential hazardous substances emergency events (Figure 1).

Ninety-five potential hazardous substance emergencies were reported for Missouri by the U.S. Coast Guard's National Response Center (NRC). Of these 95 reports, 31 (33%) met the HSEES case criteria and were entered into the HSEES database as events. Fifty-eight (61%) NRC reports had been reported to the HSEES program by another source.

Of the 341 events from all sources investigated by the HSEES Coordinator, 193 investigations were entered into the HSEES data base. One hundred ninety-one (191/99%) of these met the case definition. This is in comparison to fiscal year '95 which had 318 events and fiscal year '94 which had 193 events.

Types of releases reported were: spill, air emission, fire, explosion, threatened and other. Spills were the most common type of release followed by air emissions and combination releases that involved two or more types of release (i.e. spill and fire; fire and explosion; or fire and air emission) (Figure 2).

A total of 216 substances were released in the 191 events. The majority of events (179/93%) involved the release of only one substance. The highest number of substances released in any event was 11. The most commonly released substance was ammonia with 37 (17.1%) releases, followed by PCBs, 10 (4.6%) releases, sulfuric acid, 8 (3.7%) releases, hydrochloric acid with 7 (3.2%) releases, paint with 6 (2.7%) releases and ethylene glycol and nitrogen with 5 (2.3%) releases (Figures 3 and 4).

Events occurred throughout the state, in 54 counties and the City of St. Louis. This represents slightly over 50% of the counties of the state. Events occurred primarily in counties where there are larger cities, interstate highways and large manufacturing or mining facilities. Figure 5 shows the number of events occurring in each county.

One hundred thirty-two (69%) of the releases occurred at fixed facilities. Fifty-nine (31%) were transportation related. Of the 59 transportation-related events, 53 were ground transportation (e.g. truck, van, tractor, automobile) and 6 were rail (Figures 6 and 7). Figures 8 and 9 show the number of events occurring each month in fixed facilities and transportation, respectively for the past three years.

In Missouri, 39 counties and the City of St. Louis have interstate highways running through them. Since the majority of transportation-related events (90%) involved ground transportation, we

have taken a closer look at these events. Ground incidents occurred in 26 of the 40 counties (including the City of St. Louis) with interstate highways. Closer analysis of these incidents shows that 11 (21%) events occurred on an interstate highway. Analysis of these events shows that 6 incidents involved leaking loads or trailers along side the highway and 5 incidents were accident related. In contrast, 5 events occurred on U.S. highways, other than interstates; 7 events occurred on State highways; 6 events occurred on lettered blacktop highways; 1 event occurred on a gravel road; and 6 events occurred on city streets. Eight events occurred at the intersection of roads. Of these 8 events, 5 occurred at the intersection of city streets, 2 occurred at a U.S. highway and a lettered blacktop, and 1 at an interstate and a state highway. Nine (9) events occurred at transportation terminals (Figure 10).

Of all events, 160 (84%) occurred on weekdays. Thirty-one events (16%) occurred on the weekend. Slightly over half the events, 115 (60%), occurred between 6 a.m. and 6 p.m., with 80 (42%) occurring between the core working hours of 8 a.m. and 5 p.m., Monday-Friday. Twenty-two (12%) occurred between midnight and 6 a.m. and 29 (15%) occurred between 6 p.m. and midnight. Time of event was unknown for 25 (13%) events (Figures 11 and 12).

Evacuations were ordered in 14 (7%) events (Figure 13). The number of people evacuated was known for 9 events and unknown for 5 events. From these 9 events, 990 people were evacuated. In any single evacuation, the largest number of known people evacuated was 300 and the smallest number was 5. Seven of the evacuations involved the evacuation of affected building(s) or part of the building and seven were downwind evacuations (Figure 14). A total of 11 substances were released in these 14 events. Figure 15 shows the most commonly released substances when an evacuation occurred.

Ammonia was the most commonly involved substance, occurring in 5 events with a total of 325 evacuees. Chlorine and inorganics were involved in 3 events each with a total of 660 evacuees. Acids were involved in two releases with an unknown number of evacuees. Methyl mercaptan was involved in 1 event with 5 evacuees and ammonia, asbestos and solvents were involved in 6 events with an unknown number of people evacuated.

Twenty-three (12%) releases resulted in 58 victims. The largest number of victims associated with a release was 29. The most common type of injury reported was respiratory irritation, which occurred in 47 (81%) of the victims. Other types of injuries/symptoms included eye irritation, chemical burns, thermal burns, skin irritation, dizziness/CNS, nausea/vomiting, trauma and other (Figures 16 and 17).

Of the 58 victims, 2 died, 21 were treated at the scene, 13 were transported to a hospital but not admitted, and 22 were admitted to a hospital (Figure 18).

Forty-seven employees, 5 responders and 4 members of the general public were injured and 2 employees died (Figure 19). One release of chlorine impacted 29 victims (50%). A release involving hexachloroethane, aluminum powder and zinc oxide resulted in 11 victims (19%). Ammonia and styrene monomer were involved with 5 victims each (8%). A release of sodium hypochlorite and epoxy resin resulted in 4 victims (7%). The remaining 4 substances were involved with 1 victim each (Figure 20).

IV. MEASURE OF PROBABILITY AND SEVERITY

HAZARDOUS MATERIALS TRANSPORTATION ACCIDENT

The probability of occurrence is rated as high because of the large volume of hazardous materials being hauled over the highways and railways. This rating means that the probability of occurrence is considered sufficiently high as to assume the event will occur at least once within the expected mode of transportation.

The severity of the consequences is rated as moderate, but may be either low or high depending on the location of the accident and the time of day. This rating means injuries and/or death are expected only for exposed personnel over extended periods of time or when individual personal health conditions create complications.

Note: The severity to the environment will be different in every case. It will depend upon the amount, type and method dispensed to determine the damage to property and the environment. Close coordination between the Missouri Department of Natural Resources, EPA, the local jurisdiction and the spiller will be required to insure that the environment is determined safe again.

HAZARDOUS MATERIALS FIXED FACILITY ACCIDENT:

The probability of occurrence is rated as moderate. With all of the new regulations from EPA and OSHA along with more stringent state laws and employee awareness training this rating may be lowered to low or raised to high by the county official for individual facilities based on past performances. This rating means the probability of occurrence is possible during the expected lifetime of the facility.

The severity of consequences is rated as moderate but may be either low or high depending on the type and amount of chemical released. This means the chemical is expected to move into the surrounding environment in concentration sufficient to cause serious injuries and/or death unless prompt and effective corrective actions is taken. Injuries and/or death expected only for personnel exposed over an extended period or when individual personal health conditions create complications.

Note: The severity to the environment will be different in every case. It will depend upon the amount, type and method dispensed to determine the damage to property and the environment. Close coordination between the Missouri Department of Natural Resources, EPA, the local jurisdiction and the spiller will be required to insure that the environment is determined safe again.

V. IMPACT

The entire State of Missouri is susceptible to this type of hazard. Depending on a number of factors such as:

- Type of chemical
- Amount released/spilled
- Method of release
- Location of release
- Time of day
- Weather Conditions

This hazard could have a significant impact on the public, the environment or private property.

The impact of this type of disaster will be localized to the immediate area surrounding the incident. The initial concern will be to the people, then the environment. If there is contamination, then the spiller is responsible for the clean-up actions and will work closely with the Missouri Department of Natural Resources, the EPA and the local jurisdiction to ensure clean-up is done safely and in accordance with federal and state laws.

Local government, county and/or municipal, is more directly impacted by radiological incidents than state or federal government. Local responders are, invariably, the first on scene for any incident. Therefore, they have the responsibility to treat any injured on scene and transport them to a hospital for more complete medical care. Also, local first responders have the initial responsibility of controlling exposure of emergency workers and the public to any radioactive materials, and to contain the spread of radioactive contamination as much as possible. While clean-up of any actual spill of radioactive materials rests with the shipper (in most cases), local responders must provide site control for several hours until the responsible parties arrive on the scene.

A recent survey was completed of Missouri fire departments across the state asking their perception of their own capability to respond to a radiological incident. Out of four hundred thirty-three (433) departments surveyed, only one hundred eighteen (118) responded. Of those, twenty-one (21) believe they could adequately handle a radiological incident until proper authorities arrive.

It is clearly indicated that there are pockets of radiological response capability throughout the state. However, there are disturbing gaps in some of the main transportation corridors. It is also clear that training needs to be encouraged along these corridors. The same consideration must be given to any county located under commercial flyways or where it might be possible for a fallen satellite to leave a contaminated "footprint." (COSMOS 954 left a 200-mile footprint in the Northwest Territory of Canada in 1978).

VI. SYNOPSIS

Any disaster or emergency could result in additional concerns when it interacts with the presence of hazardous materials. A case in point was the Floods of'93, when large propane tanks in St. Louis were threatened by rising floodwaters, forcing evacuations of nearby residents in several areas. Each new emergency will need to be evaluated and top priority given first to the protection of the public, then the environment and property.

VII. MAPS OR OTHER ATTACHMENTS

Tier II Forms are filed and maintained by the Missouri Emergency Response Commission at SEMA. Site specific plans are on file with each County Local Emergency Planning Commission (LEPC). Transportation and Evacuation Routes are identified in each County Emergency Operations Plan.

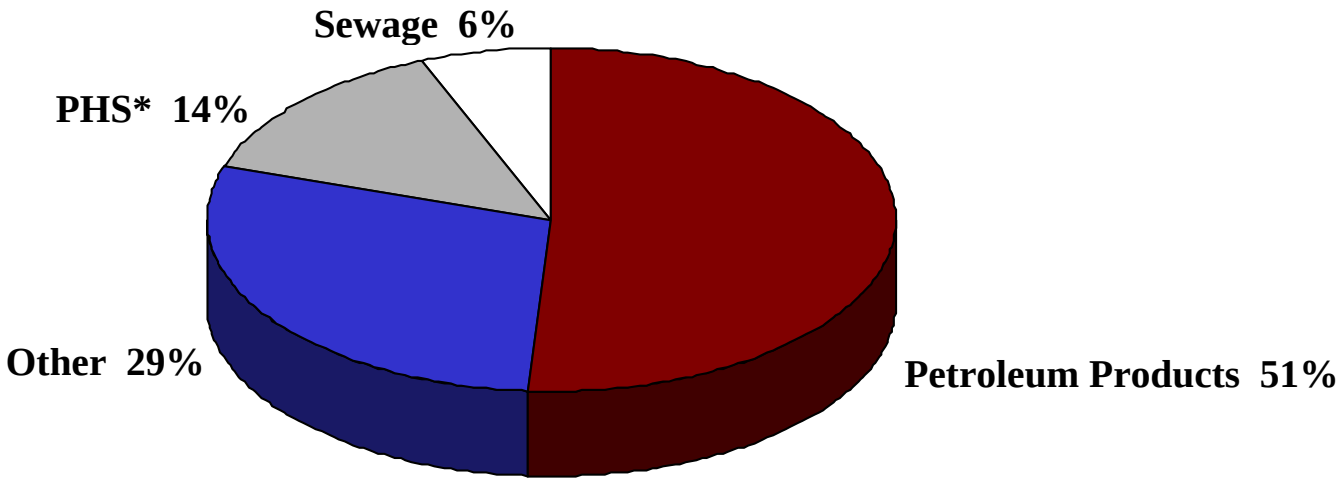
The 1995 Public Service Commission, Natural Gas Pipeline Map is on file with the State Emergency Management Agency.

Attachments to this annex include: HSEES by Missouri County and Number of Events (Figure 5), the HSEES Charts (figures 1-4, & 6-20), and Missouri Rail System Map (figure 21).

Figure 1

Environmental Emergency Response Reports Received by Missouri Department of Natural Resources by Type of Event

Oct. 1, 1995 - Sept. 30, 1996



***Potential Hazardous Substances**

Figure 2

Type of Release
MO HSEES

Oct. 1, 1995 - Sept. 30, 1996

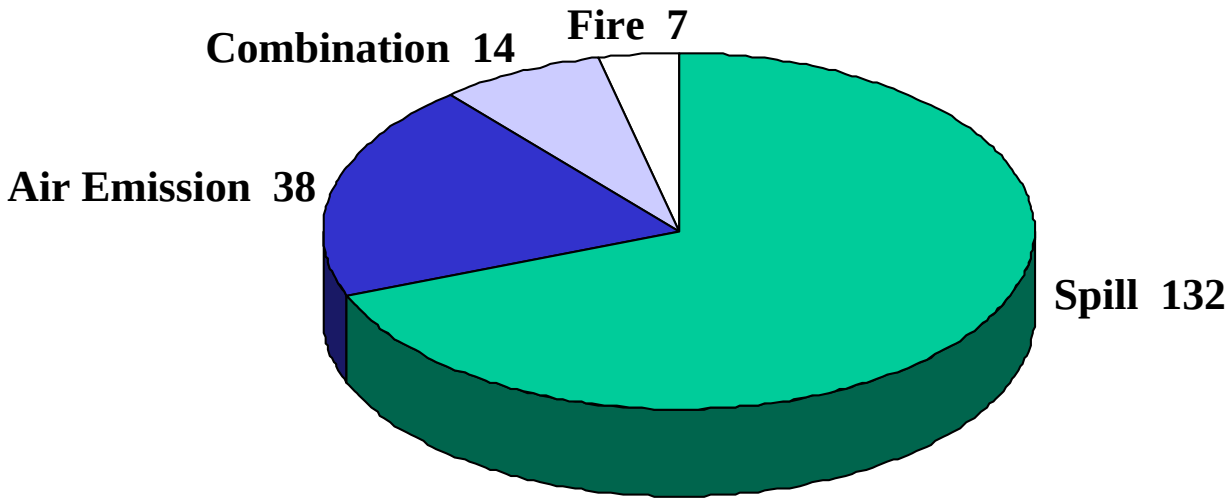


Figure 3

Number of Substances Released per Event MO HSEES

Oct. 1, 1995 - Sept. 30, 1996

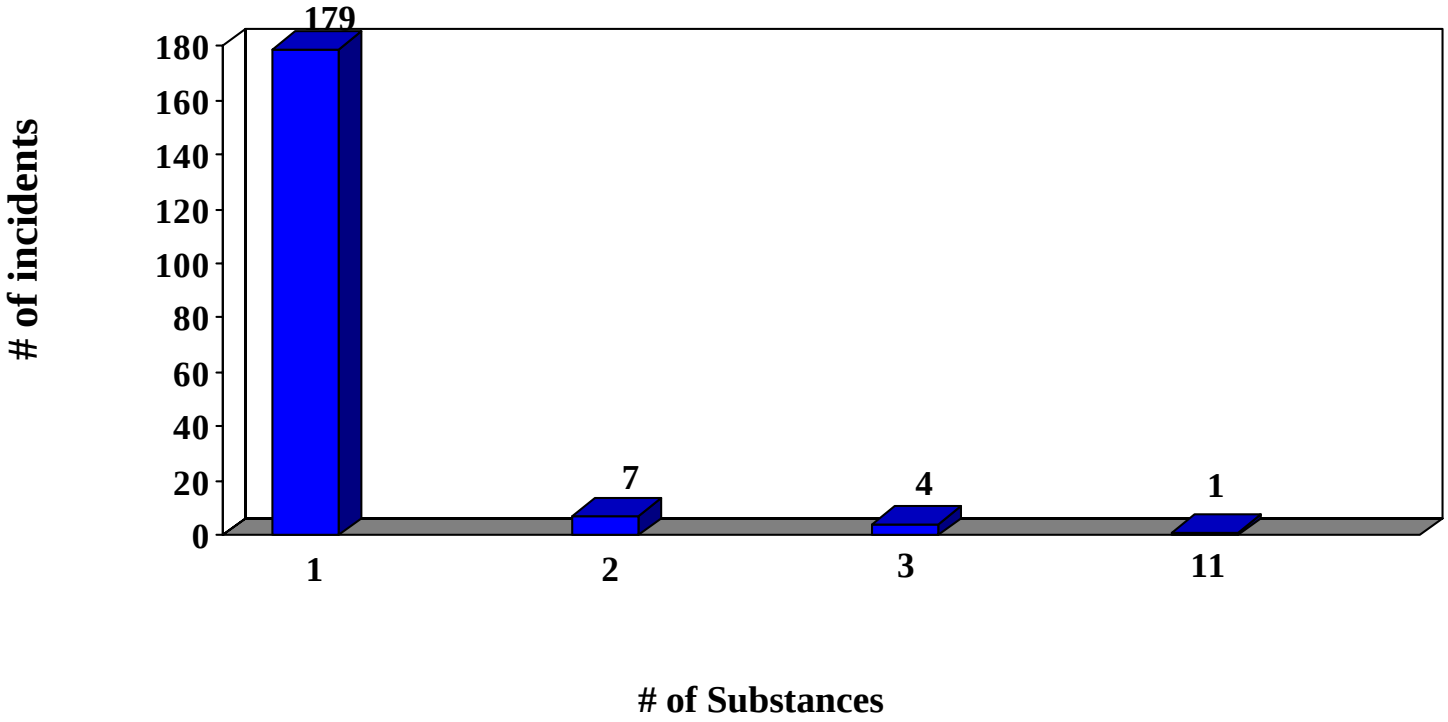
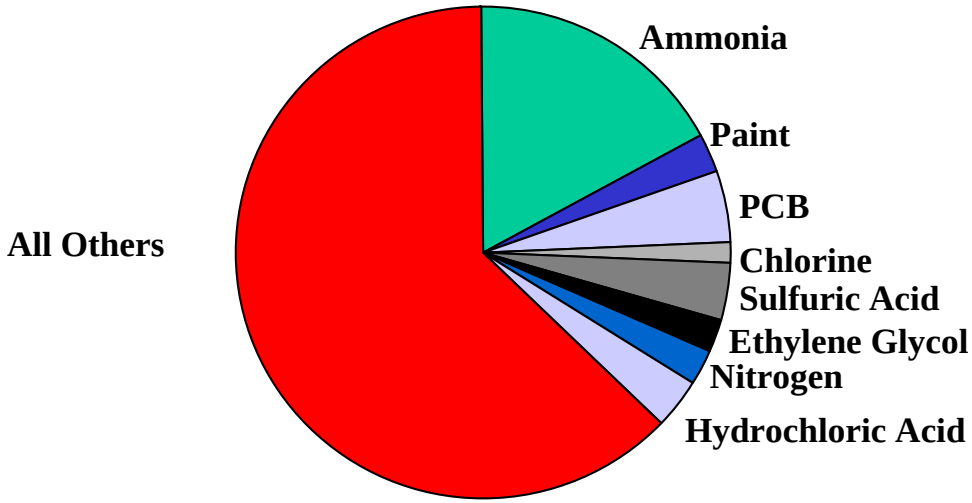


Figure 4

Most Frequently Released Substances
MO HSEES

Oct. 1, 1995 - Sept. 30, 1996



216 Total Substances Released

Figure 6

Event Type by Month
MO HSEES

Oct. 1, 1995 - Sept. 30, 1996

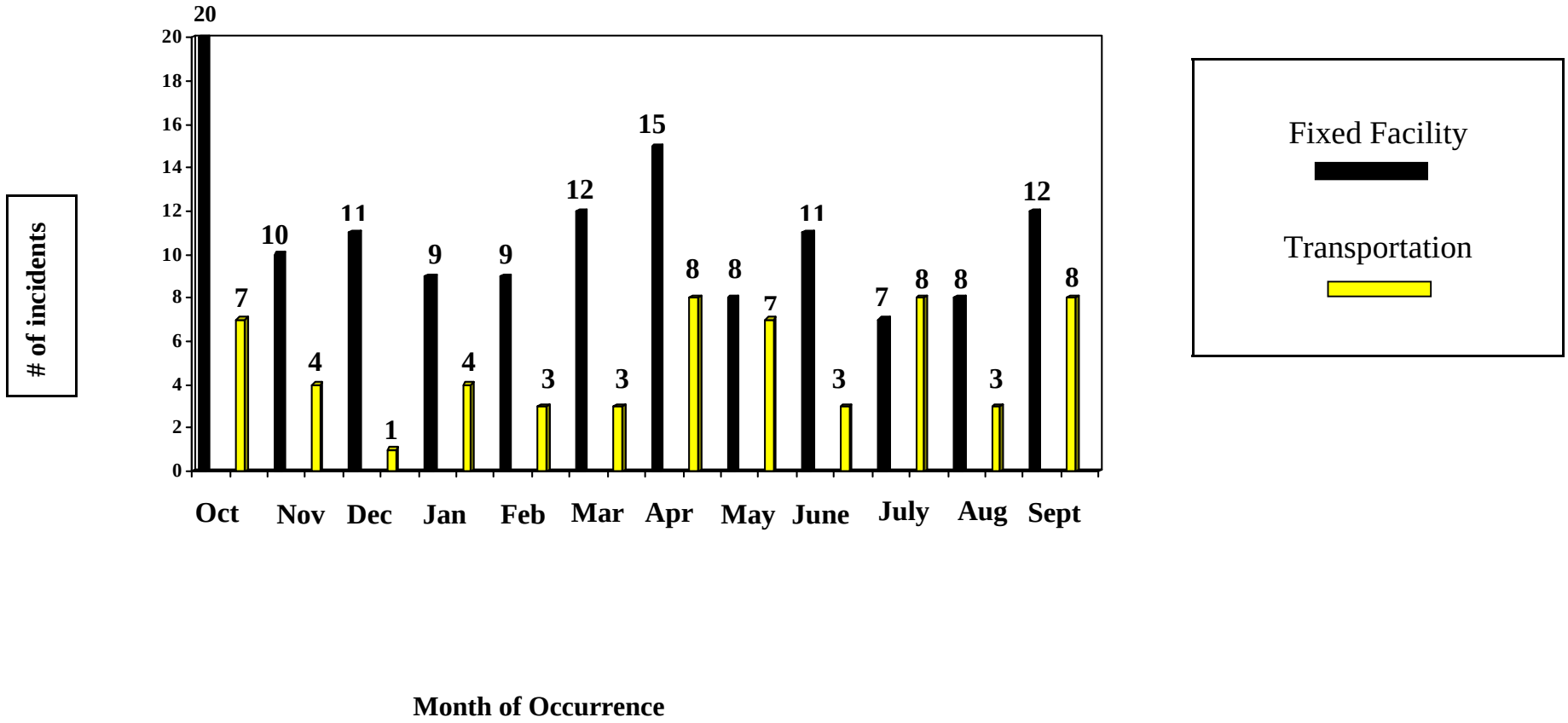
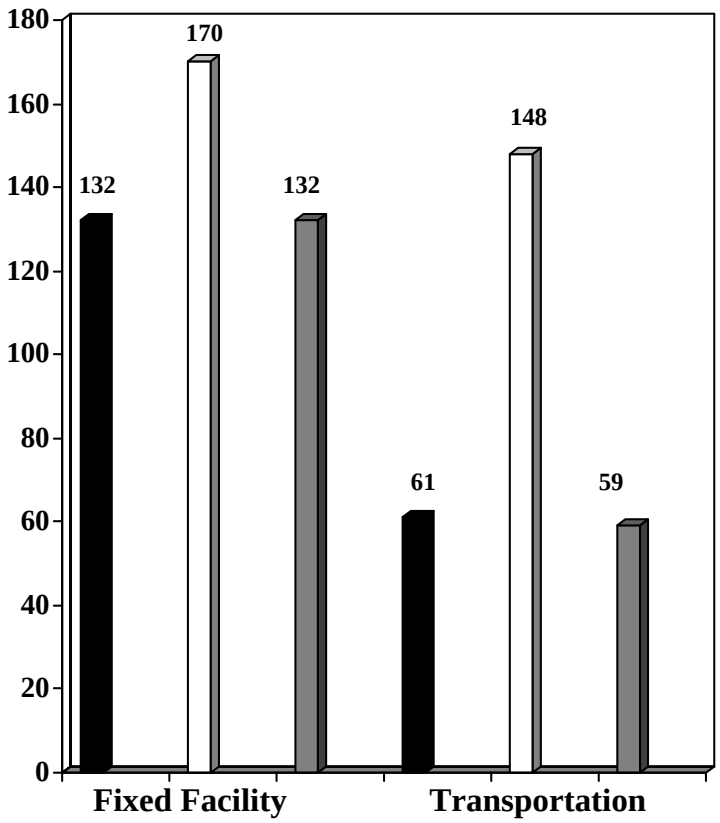


Figure 7

MO HSEES

Events by Type
(# of incidents)



Events by Type of Transportation
(# of incidents)

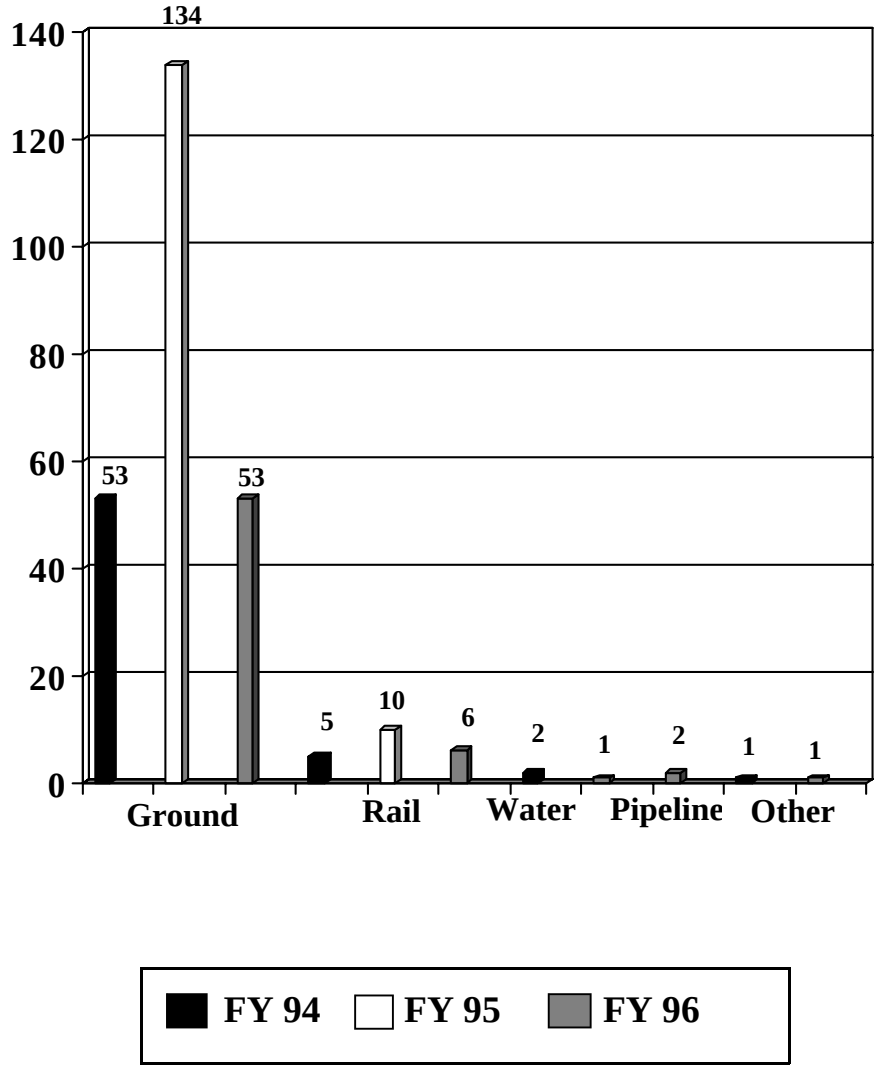


Figure 8

Fixed Facility Events by Month & Year
MO HSEES

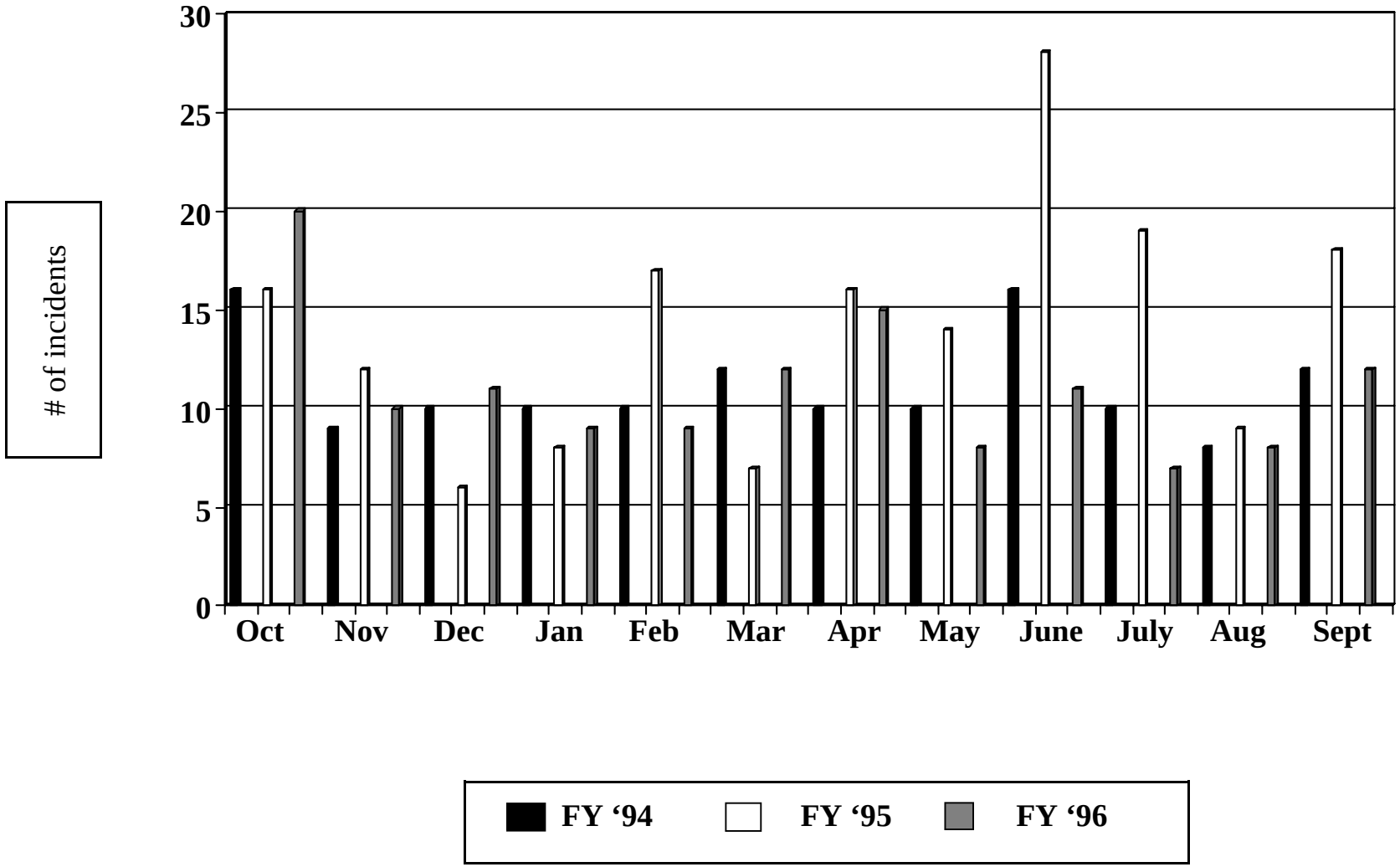
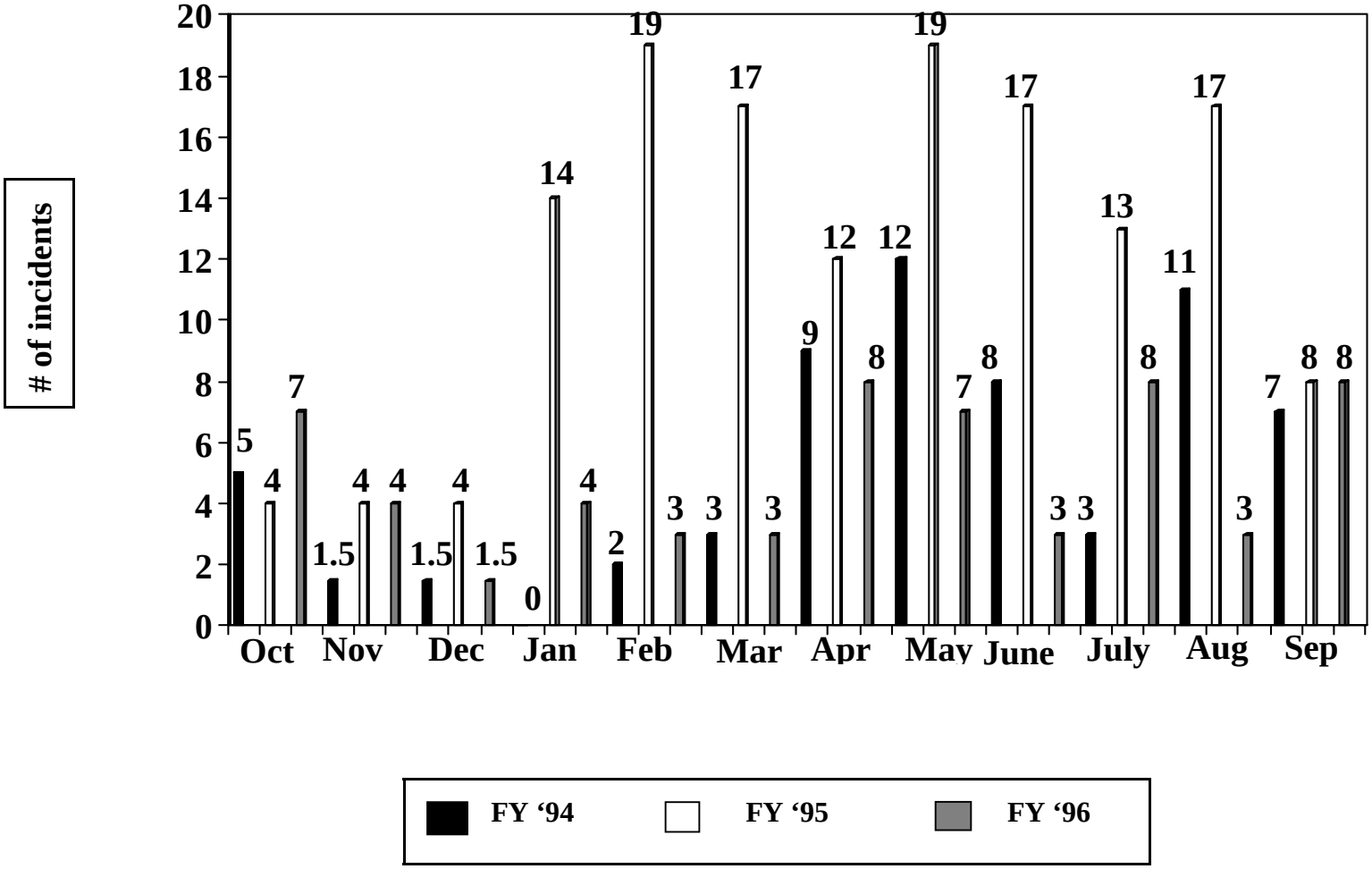


Figure 9

Transportation Events by Month & Year
MO HSEES



Note: FY '95 data includes reports from Hazardous Materials Incident System (HMIS)

Figure 10

Ground Transportation Events by Location
MO HSEES
Oct. 1, 1995 - Sept. 30, 1996

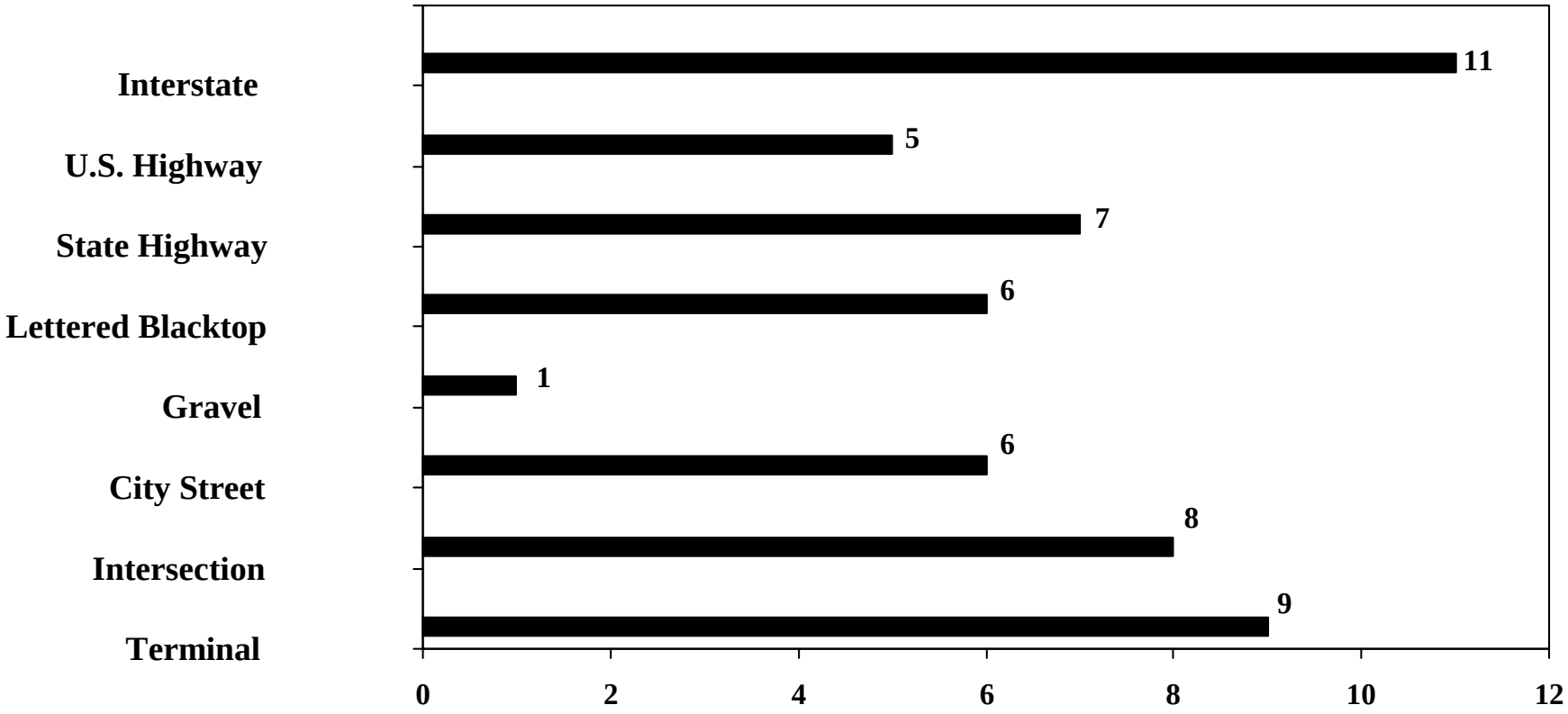


Figure 11

Events by Day of the Week
MO HSEES

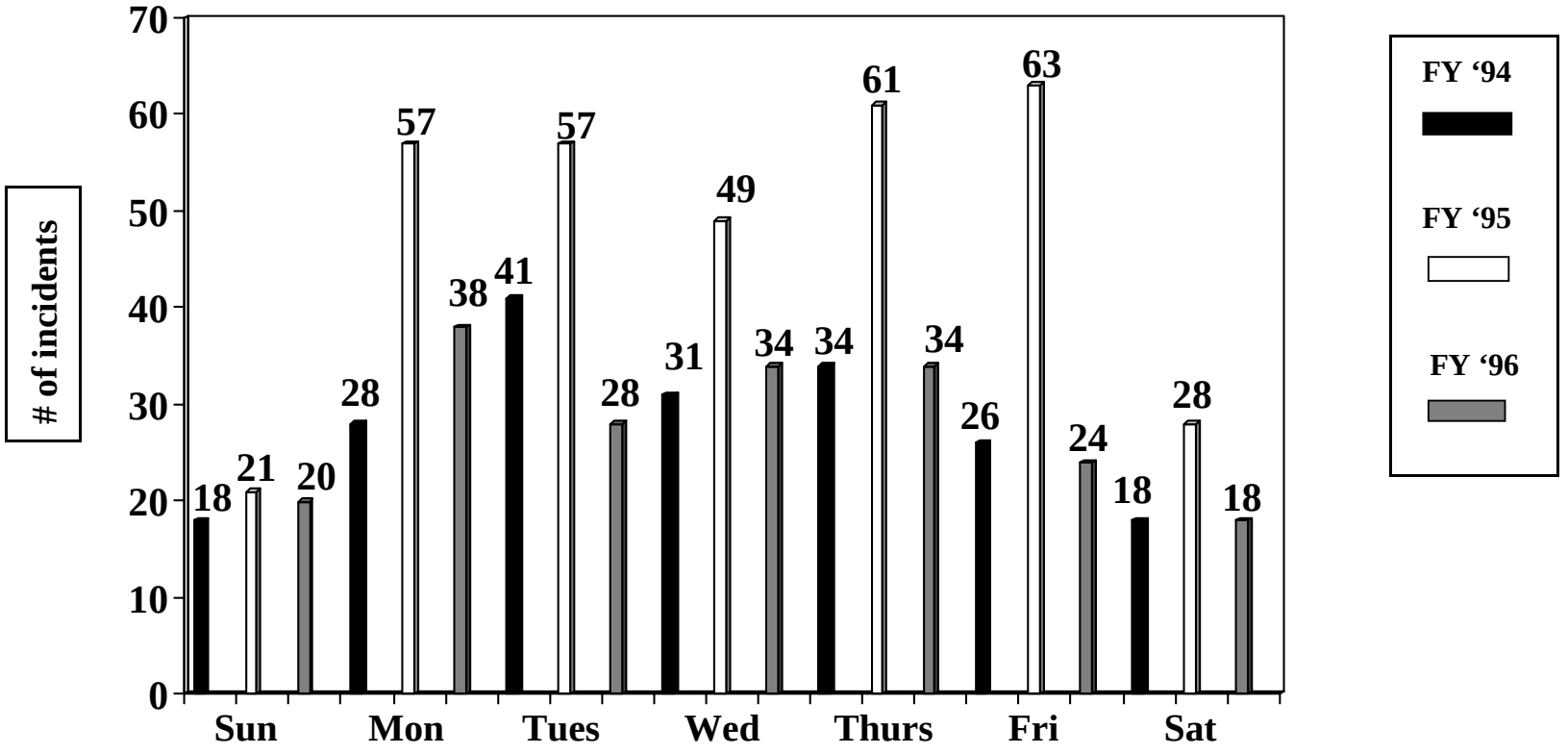


Figure 12

Events by Time of Occurrence
MO HSEES

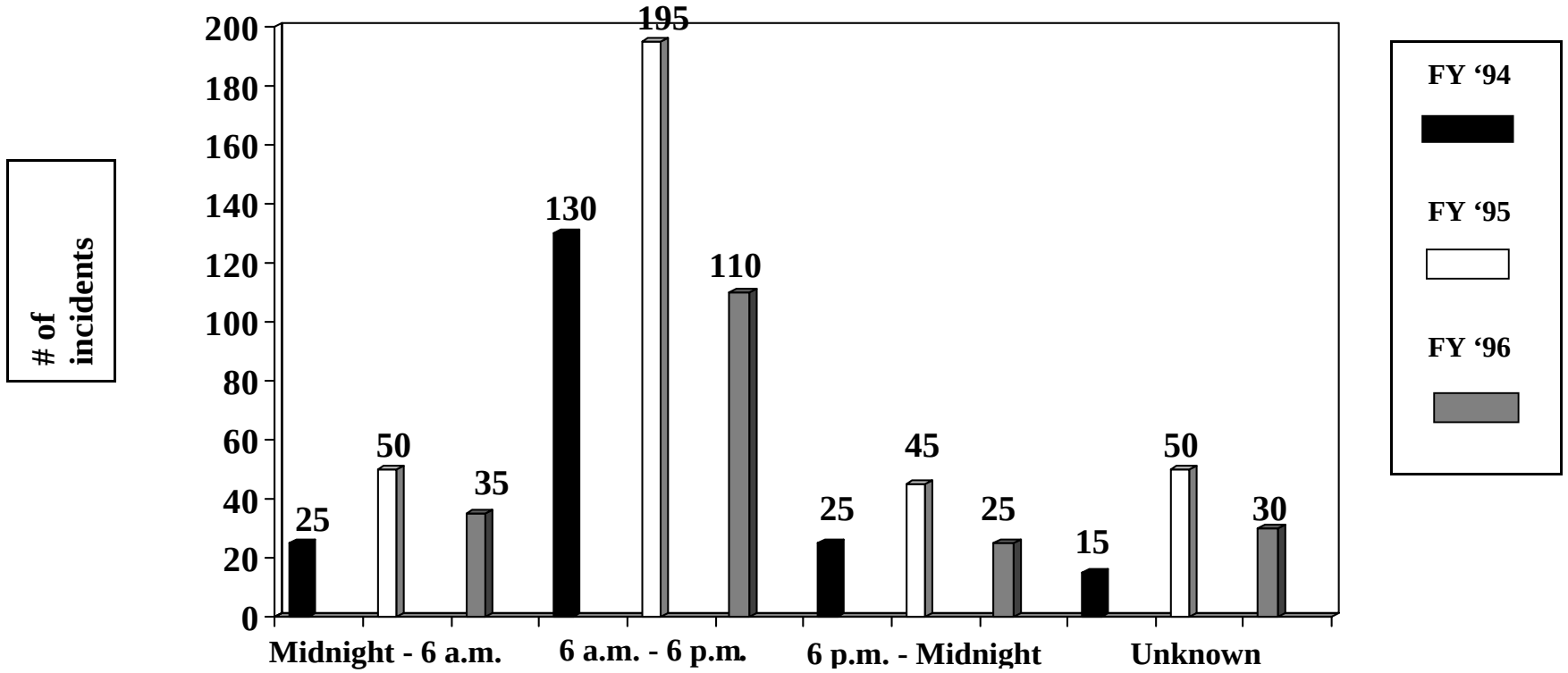


Figure 13

Events Requiring Evacuation
MO HSEES

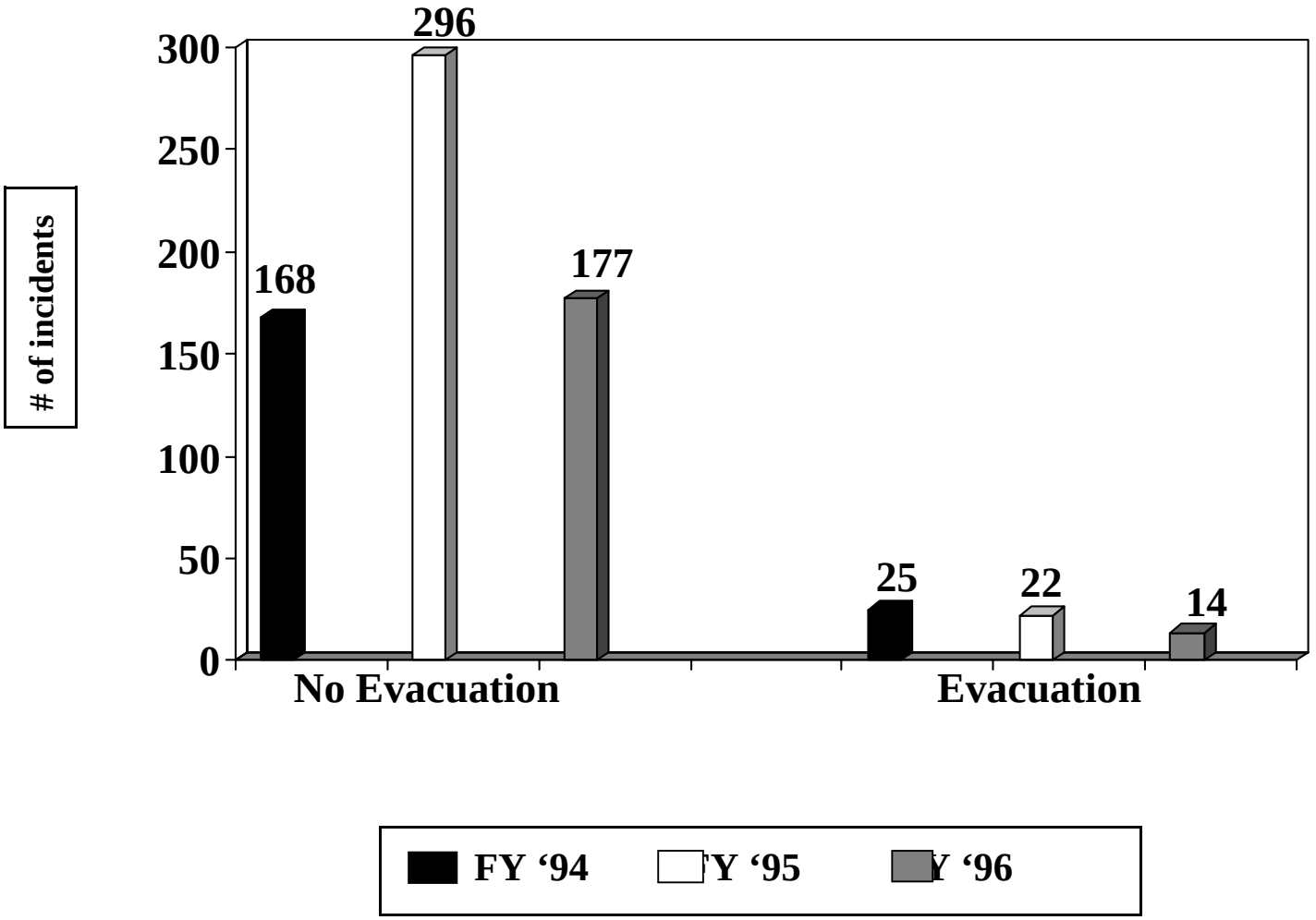


Figure 14

Evacuations by Type
MO HSEES

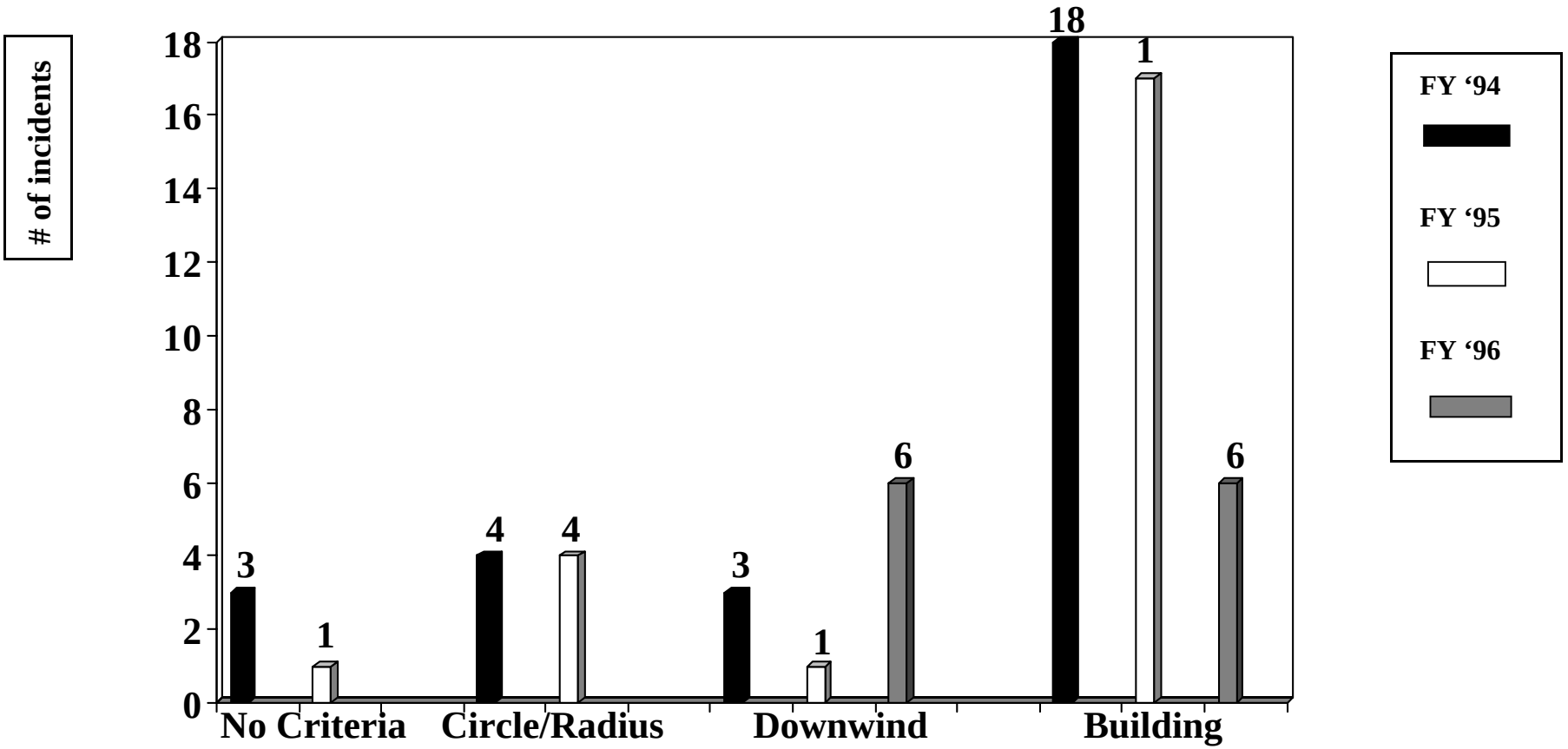


Figure 15

Most Commonly Released Substances
Events Requiring Evacuation
MO HSEES

Oct. 1, 1995 - Sept. 30, 1996

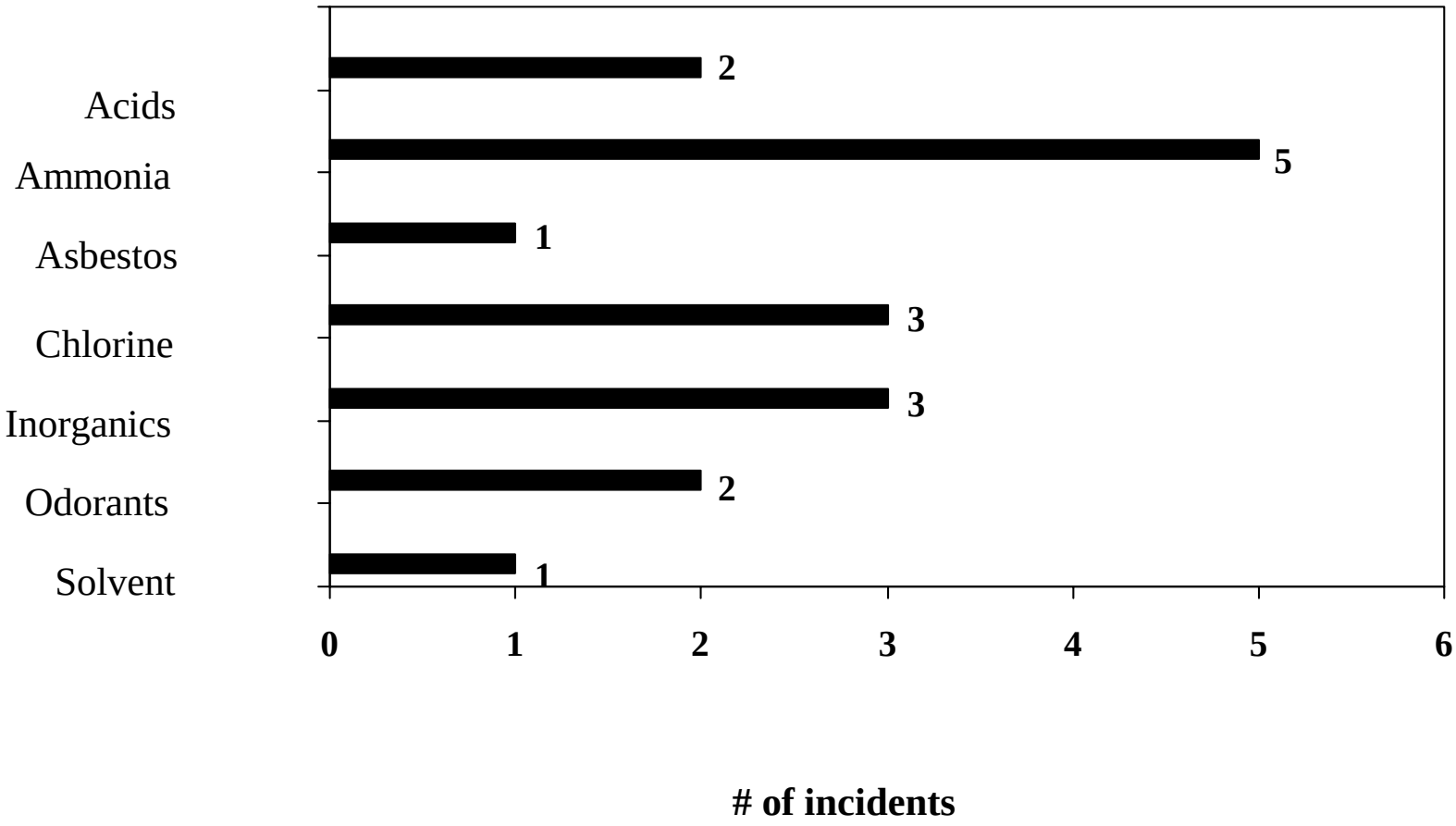


Figure 16

Events with Injuries
MO HSEES

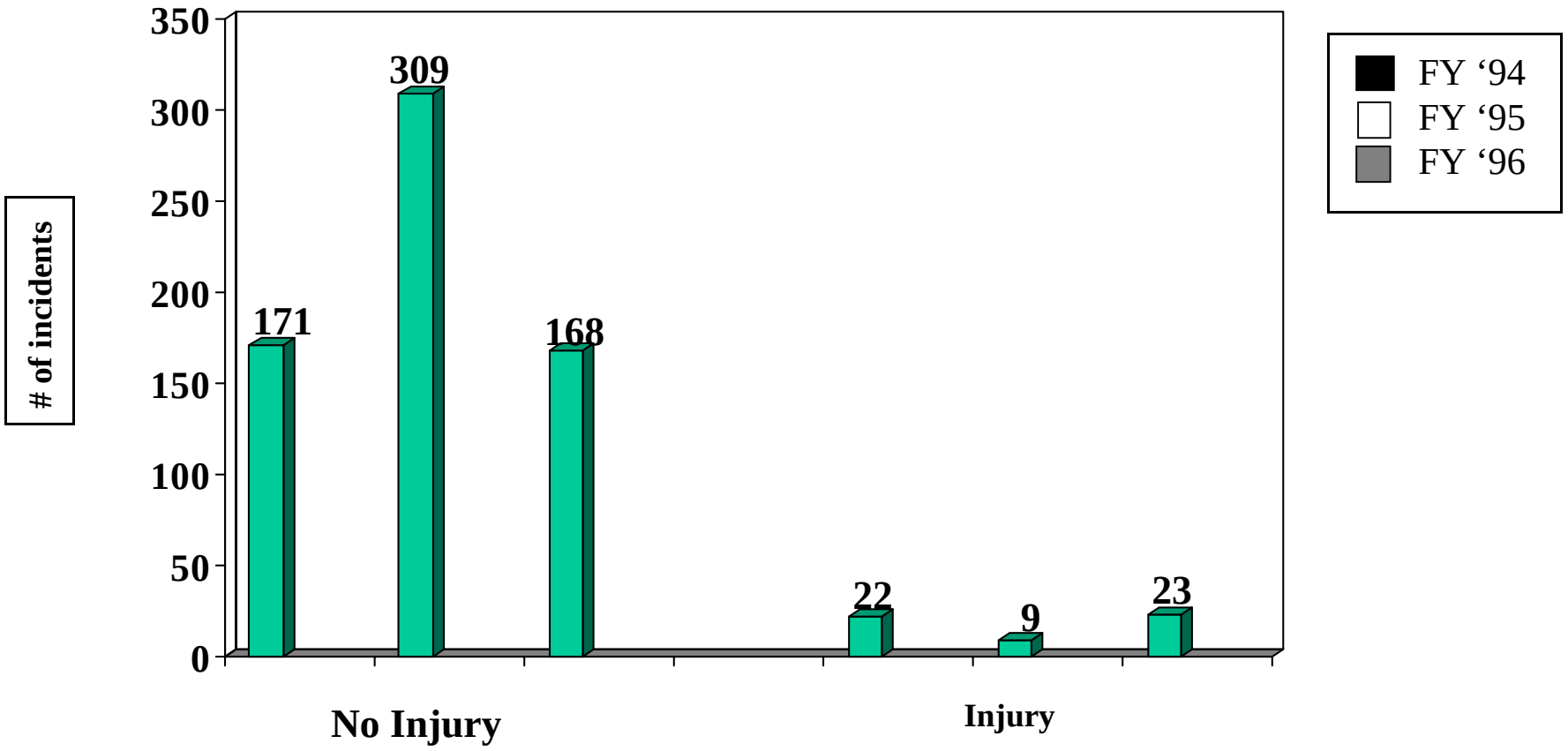


Figure 17

Types of Injuries
MO HSEES

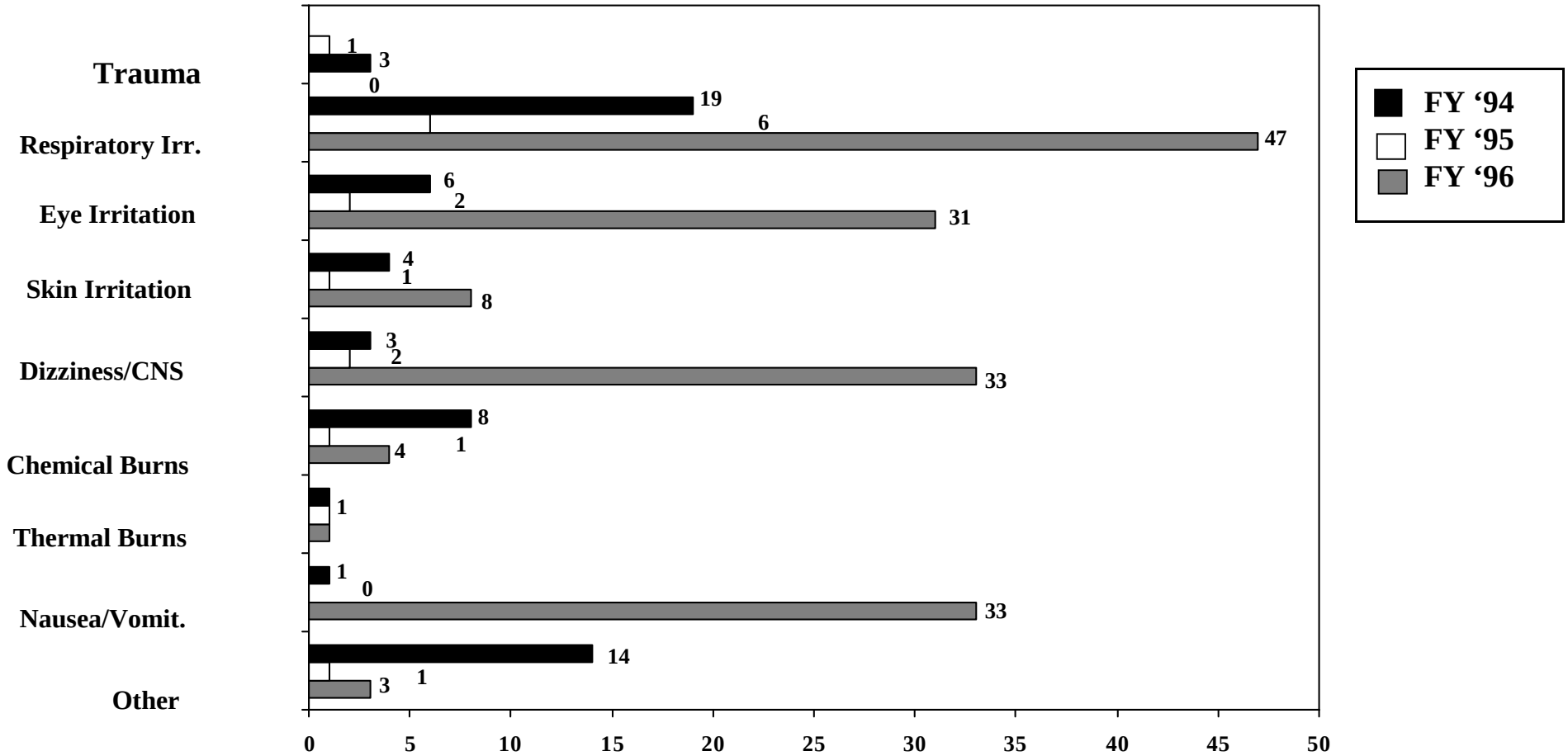
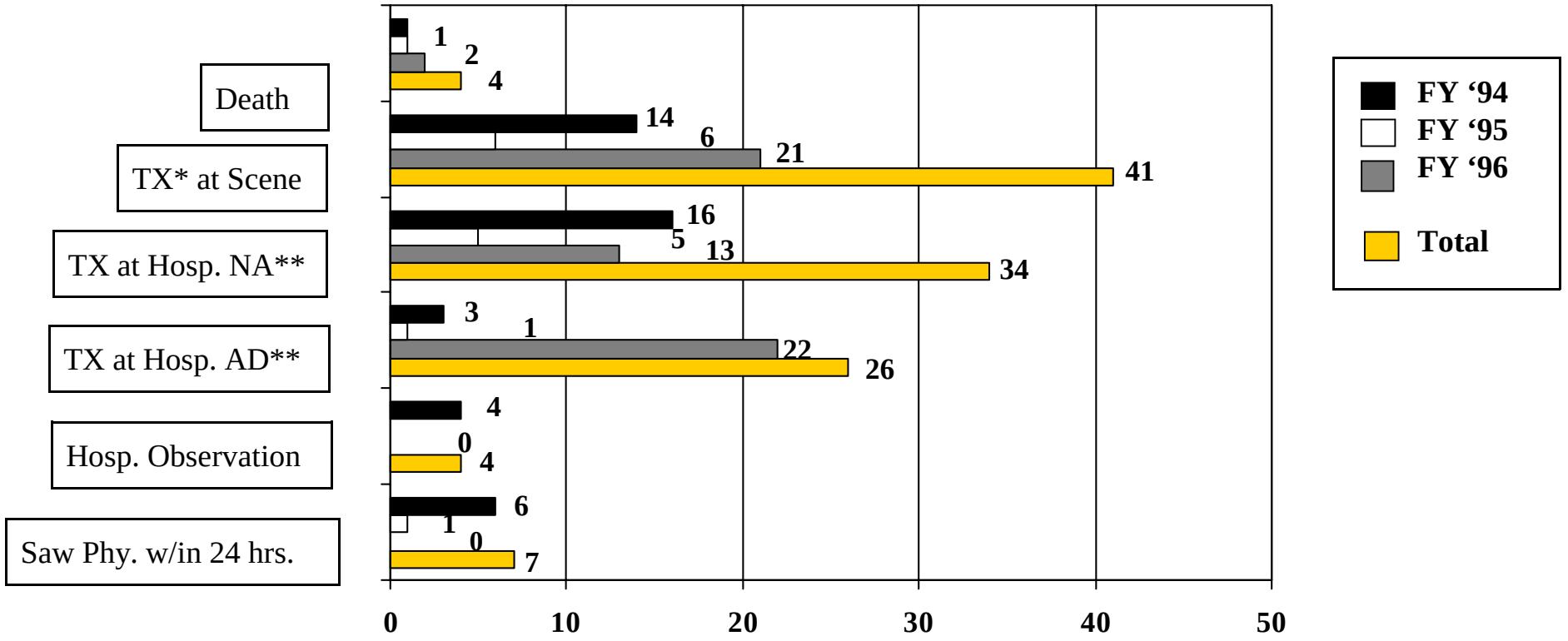


Figure 18

Severity of Injuries
MO HSEES



*Treated
**Not Admitted
***Admitted

Figure 19

Victims by Type
MO HSEES

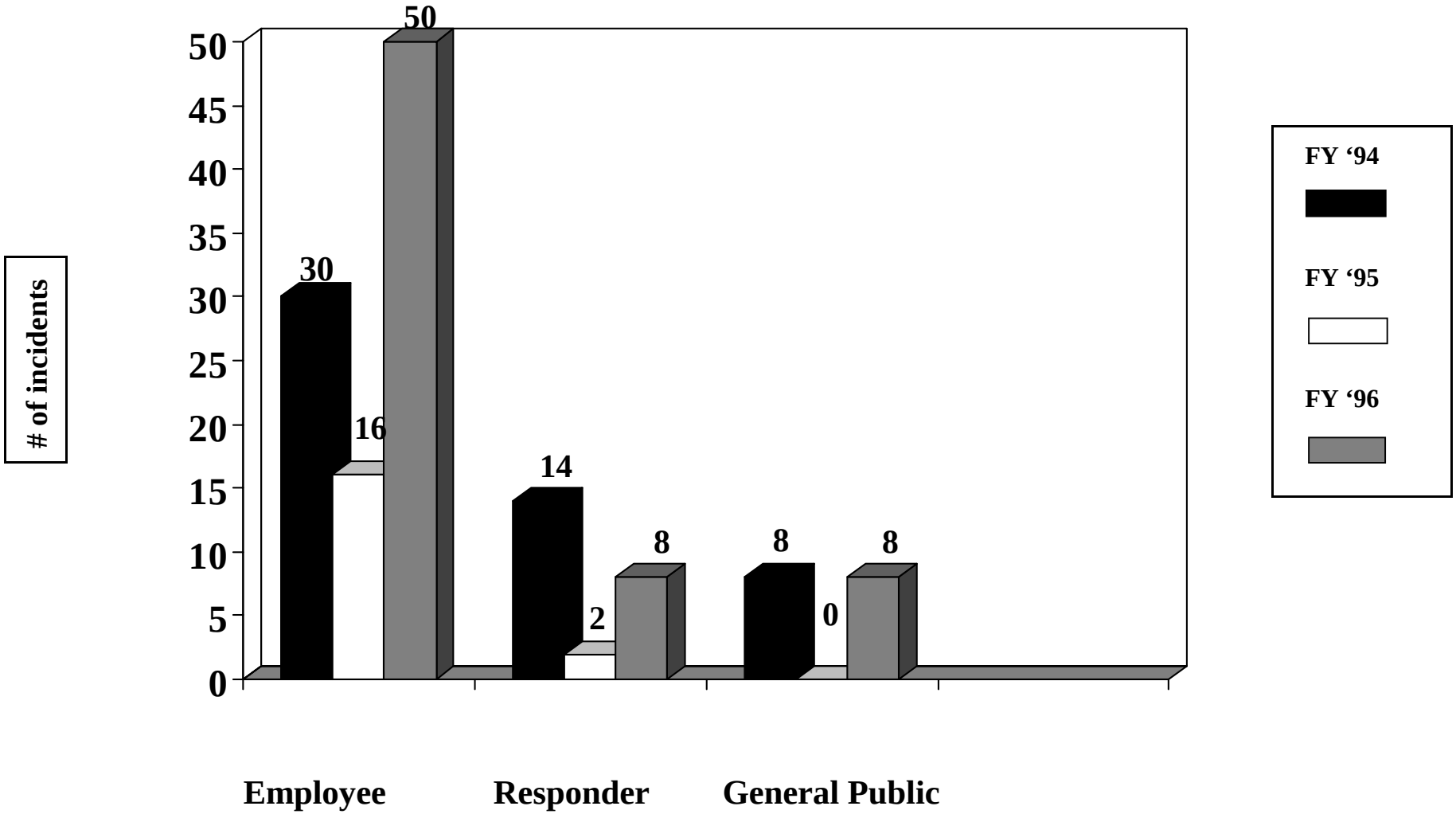
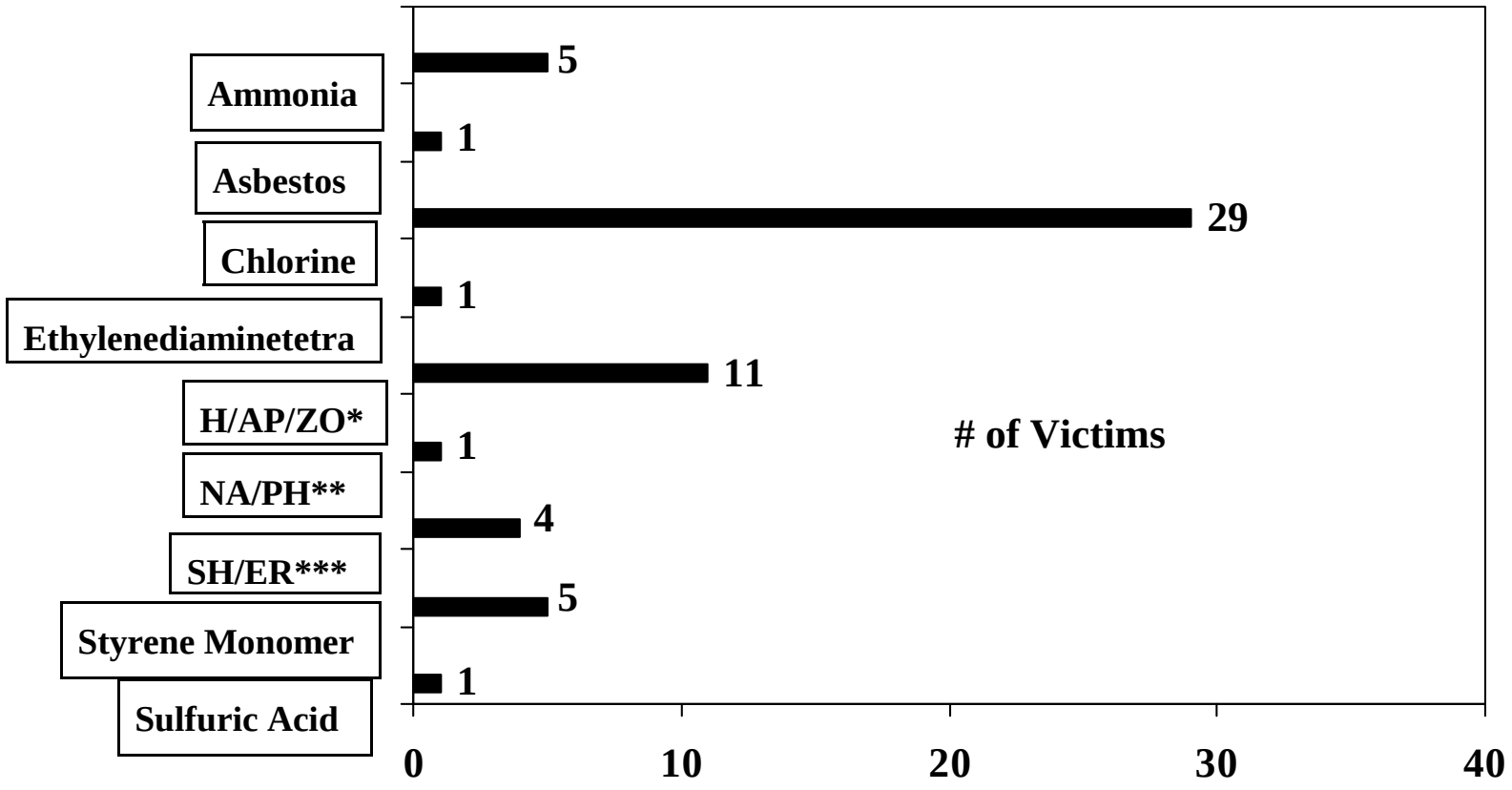


Figure 20

Victims by Substances
MO HSEES
Oct. 1, 1995 - Sept. 30, 1996



***Hexachloroethane/Aluminum Powder/Zinc Oxide**
****Nitric Acid/Potassium Hydroxide**
*****Sodium Hypochlorite/Epoxy Resin**

Figure 21

MAP

MASS TRANSPORTATION ACCIDENTS

I. TYPE OF HAZARD

Mass Transportation Accident

II. DESCRIPTION OF HAZARD

For the purpose of this study, mass transportation is defined as the means, or system, that transfers larger groups of individuals from one place to another. The important key is that we are discussing transportation accidents involving the public, not materials. Thus, mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

The State of Missouri serves as a crossroad for the United States. Missouri, being centrally located in the nation, is naturally a hub for most major airlines and other types of tourist and business travel. Many cross country travelers use Missouri terminals to connect with transport changes for the next leg of their journey. Our airways, railways and highways are used for non stop thorough fare as well.

In 1993, Missouri's largest city, St. Louis, began operating a MetroLink rail transportation system. St. Louis is located on the eastern boundary of this state. Before service began, ridership was projected at 12,000 per day. In August 1993, the system's first month of operation between 20,000 and 35,000 rode the MetroLink each day. In July 1994, the average weekday ridership topped 42,000 commuters. MetroLink carried nearly 9 million customers during its first year of operation. The largest number of people are transported during the morning and evening rush hours.

Amtrack, the state's major passenger rail carrier, utilizes tracks that cross the entire state, East to West. Though Amtrak has experienced a decline in passengers during this decade, it continues to carry a large number of passengers daily. The peak period is close to holidays or special events.

Branson, which is located close to the state's southwestern border, has become one of this state's major tourist attractions. It ranks high among the nations top attractions. By the year 2000, this area expects to attract more than ten million tourists yearly. Because Branson is a small community, tourists are more visible than in Kansas City and St. Louis. As well, there are fewer resources (number of hospital beds, fire equipment, ambulances, etc.) in a small community.

III. HISTORICAL STATISTICS

Commercial motor vehicles were involved in a significant number of Missouri traffic accidents. In 1993, 9.1% of all traffic accidents involved a commercial motor vehicle. Of fatal traffic accidents, 15.9% involved a commercial motor vehicle. A total of 155 persons were killed and 5,615 were injured in commercial motor vehicle related accidents.

Although school buses are not involved in a large number of traffic accidents in the state, they are important due to their potential for causing death and injury to young children. Of all 1993 Missouri traffic accidents, 0.9% involved a school bus or a school bus signal. A total of five persons and 784 were injured in these accidents.

Tour buses are on the increase. With Branson continuing to expand, more bus traffic can be expected. In 1993, a total of four deaths and 311 injuries occurred in bus related accidents.

IV. MEASURE OF PROBABILITY AND SEVERITY

A major accident could occur even though all safety precautions are in place. **Based on the information in the Missouri 1994 Edition of Traffic Crashes, the probability and severity of a mass transportation accident is rated as moderate.**

V. IMPACT OF THE HAZARD

A mass transportation accident could burden a local jurisdiction's available medical services. Mutual aid agreements with adjoining jurisdictions should be developed between ambulance services and the hospitals.

VI. SYNOPSIS

This type of hazard could involve hazardous materials or a fire which would compound the incident. Severe weather could also hamper response efforts.

VII. MAPS OR OTHER ATTACHMENTS

For additional information, see Traffic Crashes - Missouri 1994 edition, and 1993 Missouri Traffic Safety Compendium, which both can be obtained from the Missouri State Highway Patrol and the Division of Highway Safety.

The Missouri Gaming Commission, in conjunction with the State Emergency Management Agency, is working on the development of emergency planning procedures for riverboat casinos.

CIVIL DISORDER

I. TYPE OF HAZARD

Civil Disorder
(Riots, Protests, Sit-Ins, Marches, Demonstrations)

II. DESCRIPTION OF HAZARD

Civil disorder is a term which generally refers to groups of people purposely choosing not to observe a law, regulation or rule, usually in order to bring attention to their cause, concern or agenda. In Missouri, state statutes define civil disorder as "any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual."

Civil disorder can take the form of small gatherings or large groups blocking or impeding access to a building, or causing disruption of normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full scale riot in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group which blocks roadways, sidewalks or buildings, nevertheless interferes with public order. In the 1990's, abortion clinics, for example, have typically been the scene of these disruptive type activities in various communities across the country.

From the time the "Bill of Rights" was added to the U.S. Constitution in 1791, incidents which disrupted the public peace have figured prominently in our history. The Constitutional guarantees which allow for ample expression of protest and dissent in many cases collide with the Preamble's requirement of the government "to ensure domestic tranquility." Typical examples of such conflicting ideology include the protest movements for civil rights in the late 1960's, and the Vietnam War protest demonstrations in the mid 1970s. The delicate balance between an individual or group's legitimate expression of dissent and the right of the populace to live in domestic tranquility requires the diligent efforts of everyone to avoid such confrontations in the future.

In modern society, a series of laws have evolved which govern the interaction of its members to peacefully resolve conflict. In the U.S., a crowd (just of itself) is constitutionally protected under "the right of the people to peacefully assemble." However, assemblies which are not peaceable *are not protected*, and this is generally the dividing line between crowds and mobs. The laws which deal with disruptive conduct are generally grouped into offenses which disturb the public peace. They range from misdemeanors, such as blocking sidewalks or challenging another to fight, to felonies such as looting and rioting. Missouri law makes "promoting civil disorder in the first degree" a class C felony, according to Section 574.070 of the Revised Missouri Statutes. As stated in one provision of the law, "Whoever teaches or demonstrates to any other person the use, application, or construction of any firearm, explosive, or incendiary device capable of causing injury or death to any person, knowing or intending that such firearm, explosive or incendiary device be used in furtherance of a civil disorder, is guilty of

promoting civil disorder in the first degree."

Types of Crowds and Mobs

A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds may be classified into four general categories:

* **A *casual crowd*** is simply a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct is all but nonexistent.

* **A *cohesive crowd*** consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g. rooting for a team), they require substantial provocation to arouse to action.

* **An *expressive crowd*** is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.

* **An *aggressive crowd*** is comprised of individuals who have assembled for a specific purpose. This crowd often has leadership who attempt to arouse the members or motivate them to action. Members are noisy, threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd often include demonstrations and strikers.

A mob may be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent and lawless. Like crowds, members have different levels of commitment and there are different types of mobs.

* **An *aggressive mob*** is one which attacks, riots, and terrorizes. The object of violence may be a person, property or both. An aggressive mob may be distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails or when persons act out their frustrations after political defeat, or violent mobs at political protests or rallies.

* **An *escape mob*** is attempting to flee from something such as a fire, bomb, flood or other catastrophe. Members of escape mobs have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable terror.

* **An *acquisitive mob*** is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.

* **An *expressive mob*** is one which is expressing fervor or revelry following some sporting event, religious activity or celebration. Members experience a release of pent up emotions in highly charged situations. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a "mob mentality" sets in which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy which causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

III. HISTORICAL STATISTICS

Missouri

Fortunately, Missouri has not experienced a trend of consistent riotous behavior or disruptive civil disorder, as some other states have witnessed in the past several decades. While far from recent, Missouri's most notable incident is the famous 1954 prison riot in Jefferson City, which stands as the state's worst case example of a full scale riot. Other events in Missouri's early history, as well as those in the late 60's through this decade, indicate the state is not immune to riots, protests and social upheaval, but none were to the extent of the destruction which occurred during the '54 prison riot. Here are some brief examples of Missouri's riotous events:

* **In the spring of 1832 in Jackson County**, citizens began to show their hostility toward Mormon newcomers by stoning their houses. In July, 1833, a public meeting to determine the Mormon question resulted in demands that no more Mormons be allowed to settle there, that Mormons already residing in the county move out immediately, and that the Mormon newspaper (the Evening and Morning Star) be suspended. When the Mormon settlers refused these demands, the citizens razed the newspaper office, threw the press in the Missouri River, and tarred and feathered two Mormons. The Mormons appealed their plight to Governor Daniel Dunking, who issued a decision denying any citizen the right to take into his own hands the redress of grievances. He recommended the Mormons take their case to civil courts to uphold their rights. Incensed by this action, about 50 armed men attacked a Mormon settlement called Big Blue near Independence on October 31, 1833, beating several of the men and destroying 10 homes. Hostilities continued the next two nights. On November 4, a band of citizens fought

about 30 Mormons at Big Blue, with two citizens killed and one Mormon also fatally wounded. Feeling they were outnumbered, most of the Mormons left the county as a result. The few who remained eventually left as well, due to continued threats and hostilities.

* **In 1906 on the night before Easter Sunday in Springfield**, a mob of 6,000 fueled by alcohol and rumors of a white woman's rape, battered down the jailhouse doors and carried away three black men who were then hanged in the town square. Within hours, new rumors spread that black neighborhoods were about to be destroyed. Hundreds of black people fled before the state militia arrived to restore order. In the months that followed, a grand jury indicted more than a dozen people
for the hangings, and the story of the woman's attack proved to be untrue. Only one person went to trial, however, and the jury deadlocked without reaching a verdict. In her book about the incident and its aftermath, "Many Thousand Gone," Katherine Lederer notes that until 1906, Springfield had a thriving black population which has never really recovered since that time.

* **On September 22, 1954, a full scale riot broke out at the Men's State Penitentiary** in Jefferson City at about 6 p.m., after an inmate released several prisoners with keys he had obtained from a guard by a ruse. At 7:00 p.m., all available State Highway Patrolmen were directed to report to the penitentiary as quickly as possible to quell the riot. Several buildings and vehicles were burning at that time, and some 500 inmates were loose, hurling bricks, yelling and attempting to escape as troopers arrived. Both chapels were ablaze, as well as several prison shops and factories. Seeing the fires, which were visible at dusk from some 20 miles away, prisoners at the Algoa reformatory and the women's prison staged separate rebellions there. Damage to state property at those facilities were minimal, but it was a different story at the main prison, where only cellhouses and buildings equipped with sprinklers survived. By 11:30 p.m., 285 patrolmen in 202 cars were on scene there, and by midnight, some 100 St. Louis policemen carrying submachine guns had arrived by special train. They surrounded B and C cellhouses - the only halls in which guards were still held hostage. Highway Patrolmen and arriving National Guardsmen took up their position on rooftops overlooking the quadrangle - a yard between the larger cellhouses. From that vantage point, they opened fire, seriously wounding many inmates in the exchange. Shortly after 7 a.m. the next day, the last guard taken hostage was released and the rioters, having no alternative, gave up shortly thereafter. By mid-morning, there were 2,000 police officers and National Guardsmen on duty at the prison. When the riot was finally over, three inmates had been killed, and 21 wounded by gunfire. Another prisoner was murdered by stabbing and beating, and eight others were injured in fighting with each other. Five buildings were completely destroyed and two others partially destroyed, resulting in more than $10 million in losses to state property.

* **On October 23, 1954, another riot occurred at the State Penitentiary** while state troopers were still technically operating the institution. This melee was between white and black inmates, starting over food. Bricks began to fly, followed by gunfire from the troopers. Some thirty-five prisoners were wounded in that incident.

* **On the evening of March 19, 1958 at Algoa Intermediate Reformatory**, east of Jefferson City, quick action by then Governor James T. Blair and a contingent of state highway patrolmen with riot guns quelled a potential inmate uprising. The governor himself and the patrolmen entered the facility amid reports of unrest following the resignation of the institution's acting superintendent. When no trouble occurred, the troopers were removed after about two hours.

* **On April 9, 1968, the Kansas City Police Department** requested the help of the Missouri Highway Patrol in quelling rioting, bombing and looting in the eastern part of the city in the wake of the Martin Luther King assassination. Over 200 officers reported to the staging area at District Four of the State Highway department to receive their assignments, and began patrolling the downtown area. Officers arrested numerous persons for charges ranging from curfew violations to felonious assault. They remained on duty for 10 days until peace was restored.

* **Twice in May 1969, demonstrations at Lincoln University** in Jefferson City resulted in some 200 Highway Patrolmen being called to the scene to combat arson, sniper fire and vandalism on campus. The Student Union was burned during those demonstrations.

* **On February 17, 1975 at Algoa Intermediate Reformatory**, a minor riot broke out once again, resulting in tear gas being thrown into dormitories at the institution. Three prison officials suffered minor injuries, and one inmate required stitches to close a wound. There was about $5,000 in property damage during the incident.

* **In December 1977 and January 1978 in Southeast Missouri**, farmers making up an American Agricultural Movement staged demonstrations to protest what they felt were unfair prices for their products, maintained by government price supports. The rallies continued through April 1978 with picketing, tractorcades and stoppage of highway traffic throughout the area, despite high winds, ice and snow. More than 300 farm tractors were involved in at least one of these actions. On January 11th, seven farmers were arrested by Highway Patrol troopers on Interstate 55 near Hayti and charged with failure to obey a reasonable request, assault, and damaging state property. Four others were arrested on I-55 near Caruthersville for driving their pickup trucks slowly side by side, preventing traffic from passing. Twenty-five farmers with their tractors were involved in a fracas with 12 officers near Hayti. Two patrol cars were damaged, and one officer sustained minor injuries when shoved by an irate farmer into the path of a road grader.

On April 29, 1992 in Warrensburg, racial tensions mounted following the announcement of the controversial Rodney King verdict. The Johnson County Emergency Operations Center was activated for several hours as police remained in an alert status for a potential serious disturbance. Military police from nearby Whitman Air Force Base were also

placed on standby alert status, but fortunately no major problems took place.

United States

Incidents of civil disorder which erupted into violence are an indelible part of American history, spanning several centuries. In the years just prior to the Revolutionary War, in March 1770, a riot occurred when Boston citizens jeered and taunted British soldiers and began throwing things at them during a demonstration. Five people were killed when the troops fired during the incident, which became known as "The Boston Massacre." Three years later, on December 16, 1773, a group of Boston citizens protested the British tax on tea to the colonies by throwing it overboard. The "Boston Tea Party" was a harbinger of troubles that eventually led to the Revolutionary War.

On May 4, 1886, another violent event occurred in Haymarket Square in Chicago when a confrontation took place between police and strikers at the McCormick reaper works. A bomb was thrown and a gun battle erupted, during which seven police officers and four workers were killed. Many police and civilians were also injured in what became known as the "Haymarket Square Riot."

Controversy over civil rights and the unpopular war in Vietnam during the 1960's and '70's resulted in one of the most turbulent periods in American history. During this same time frame, major riots occurred in Los Angeles in 1965, Detroit in 1967, Chicago in 1968 during the Democratic National Convention, Santa Barbara, California in 1970 and East Los Angeles, California in 1970 and 1971, as well as a major prison riot at Attica, New York in 1971. Violent rioting once again erupted across the country on April 29, 1992 when four police officers were acquitted after being accused of beating a black suspect (Rodney King). Also in recent years, issues such as abortion, gay rights, immigration and gun control have generated great public debate and resulted in many mass assemblies and demonstrations.

IV. MEASURE OF PROBABILITY AND SEVERITY

Probability

Day in and day out in any big city, police blotters will reflect the existence of a fairly steady background of theft, mugging, arson, and homicide. But this jumble of criminal malfeasance does not amount to a "riot," as riots are the coordinated act of many people. In their article on "Understanding Riots" published in the Cato Journal (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd of itself is not an incipient riot, merely because it assembles a great many people. In Illinois, for example, Chicago's Grant Park is the scene of a fireworks display that usually attracts about one million spectators. In some areas of the grounds, their article reports, people are literally packed together like sardines. But whatever its discomforts, (loud, unmanageable, extensive alcohol consumption, etc) the Grant's Park public assembly has so far each year remained only a crowd, not an incipient riot.

Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt, which include certain kinds of high profile events. In fact, incidents can become signals simply because they have been signals in the past. In Detroit, for example, Devils Night (the night before Halloween) has in recent years become a springboard for multiple, independent and almost simultaneous act of arson. With any conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst -- a sort of entrepreneur to get things going." A typical action is the breaking of a window (a signal that can be heard by many who do not necessarily see it). Someone will throw the first stone, so to speak, when he calculates the risk of being apprehended has diminished to an acceptable level. This diminished risk is generally based on two variables - the size of the crowd relative to the police force, and the probability that others will follow if someone leads. Once someone has taken a risk in getting things started, the looting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest, the authors conclude.

Nationwide, riots are apt to be more or less a recurrent, if unpredictable, feature of social life. Without question, Missouri will continue to experience future episodes of marches, protests, demonstrations, gatherings, etc. in various cities/communities which could lead to some type of disruptive civil disorder from time to time. However, based on the state's general history of civil disturbance and the various human factors noted above, **the probability that such incidents will develop into a full-scale riot is considered low.** Regarding penal institutions, much has been done in Missouri and other states to alleviate conditions which are underlying factors in many riots (prison overcrowding, poor treatment of inmates, lack of grievance procedures, etc.). The State has for several years now been building new prisons, or expanding facilities to create more space and otherwise improve its facilities for its inmate population. Plans are now being considered for a new men's maximum security prison to replace the130-year-old Jefferson City Correctional Center (site of the '54 riot), with several potential sites also being examined by the State.

Severity

Should Missouri experience future incidents of disruptive civil disorder or rioting, **the severity of a given event could range from low to high, depending on many factors.** A spirited demonstration which gets out of hand may result in several arrests, minor damage to property (police vehicles with broken windows, etc), some injuries, and manpower/overtime costs for police, fire, and other response services. To a greater extent, the threat of urban or inter-city riots have the potential for millions of dollars in property damage, possible loss of life and serious injuries, and extensive arrests. Sustaining police at the scene for extended periods, and possibly mobilizing State Highway Patrol and National Guard units, can add to the extensive manpower costs. Still, such riots tend to be confined to a single site or general area of a

community, rather than multiple locations or several areas of the state at the same time. Once a riot has occurred, police in other cities are generally on standby for possible riotous conditions and are better able to alleviate potential disturbances before they develop into full scale riot events.

V. IMPACT OF THE HAZARD

Overall, it appears there is great truth in the adage that "violence begets violence," because people who see violence around them begin to see this as a valid way of settling problems. The so- called "wilding incident" in New York's Central Park, where a group of young men savagely gang raped and almost murdered a female jogger, may be an example of how group dynamics can push individuals to do things beyond what they would be likely to do alone.

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell promptly. The rules of Constitutional law set stringent limits on how police officers may behave toward those whom they try to arrest. Restraint also plays a crucial part in avoiding any action that "fans the flames." Initial police presence is often undermined by the fact that, due to normal budget constraints, forces will be staffed below the peak loads needed to bring things back under control. At this point, the riot may continue to flow until enough state police and/or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to lives and property may have already taken a high toll.

VI. SYNOPSIS

In the wake of numerous urban riots in the late 60's and beyond, a unique approach in law enforcement began to emerge as a viable means to help reduce the risk of such riots in the future. Known as "Community Policing," its philosophy rests on the belief that reducing and controlling serious crime requires the police to pay renewed attention to the entire matrix of problems that allows serious crime to occur. In its comprehensive report following the devastating '67 Detroit riot, for example, the Kerner Commission noted that police "cannot, and should not, resist becoming involved in community service matters." The benefits to law enforcement, and public order, the Commission says, include the following:

* Because of their "front line position" in dealing with ghetto problems, police will be better able to identify problems in their community that may lead to disorder.

* They will be better able to handle incidents requiring police intervention.

* Willing performance of such work can gain police the respect and support of the community.

* Development of non-adversary contacts can provide the police with a vital source of information and intelligence concerning the communities they serve.

In his paper entitled "Preventing Civil Disturbances: A Community Policing Approach," Michigan State University professor Robert C. Trojanowicz says Community Policing can reduce the potential for riots, beyond simply reducing racial tensions between the police and the black community. The organizational strategy of Community Policing, he writes, "requires freeing some police officers from the isolation of the patrol car, so they can work directly in the community and enlist them as partners in the process of policing themselves. It addresses the need that everyone in the U.S. deserves to live in a safe and stable community, free of drugs and violence, and reminds us that "until we are all safe, no one is safe." Four basic ways Community Policing can help in riot prevention, the author says, are:

* It provides a means of gathering superior intelligence that allows us to identify areas at risk, the level of threat in those areas, and weaknesses and strengths within the community.

* It provides the police with a way to address those weaknesses, which often include crime, violence, drugs, fear of crime, disorder, neighborhood decay, and juveniles at risk.

* It reaches out to law-abiding people in the community and involves them in the police process, serving as the vital link required to enlist their help in actively promoting order and stability.

* It reduces the overall risk to riots by improving the relations between the police and the black community.

A Community Policing Officer (CPO), the author notes, is a full-fledged law enforcement officer who makes arrests, but is further challenged to find new ways to address old problems. CPOs act as community advocates for needed neighborhood services (prompt trash pickup, demolition of abandoned buildings, etc.), and serve as community liaison to public and private agencies, Trojanowicz writes. "This can mean linking troubled families to affordable counseling services, linking the homeless to shelter, or tapping local business to provide donated supplies for projects to beautify the area." The initiatives are bounded only by the collective imagination of the CPO and the people in the community and their local needs, the author concludes.

VII. MAPS OR OTHER ATTACHMENTS

None.

TERRORISM

I. TYPE OF HAZARD

Terrorism

II. DESCRIPTION OF HAZARD

Terrorism, as defined by the Federal Bureau of Investigation (FBI), includes: "the unlawful use of force or violence, committed by a group(s) of two or more individuals, against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives."

According to the FBI, there are two types of terrorism:

1. Domestic Terrorism--involves groups or individuals whose terrorist activities are directed at elements of our government or population without foreign direction.

2. International Terrorism--involves terrorist activity committed by groups or individuals who are foreign-based and/or directed by countries or groups outside the United States or whose activities transcend national boundaries.

Forms of Terrorism

Terrorism can take place in various forms, depending on the technological means available to the terrorist group, the nature of the political issue motivating the attack, and the points of weakness of their target. Potential terrorist actions include:

- Bombings--large scale, such as the Oklahoma City bombing, or small-scale, such as a letter bomb.

- Airline attacks--bomb on board, such as the Pan Am Flight 103 over Lockerby, Scotland, a surface-to-air missile attack, or a hijacking.

- Nuclear/Biological/Chemical attacks--nuclear or biological weapons may get into the hands of terrorists, as well as chemical materials, such as the sarin gas attack in the Tokyo Subway Station.

- Infrastructure attack--Amtrak Train derailment in Arizona, contamination of drinking water, and electronic sabotage (such as computer viruses which could dismantle our financial institutions or even our air traffic control systems).

- Arson--recent outbreak of church burnings. (Although Missouri has experienced 15 deliberately-set fires, none have been determined to be terrorist or hate-crime related.)

- Kidnappings/Assassinations--since these are generally against specific individuals, their effect on emergency management operations may be minimal in terms of response.

Domestic Terrorism Trends

According to the FBI, the following trends have been observed regarding domestic terrorism:

1. **Special Interest Terrorism**--groups that seek specific issue resolutions rather than widespread political changes. Their causes may or may not be criminal, but the means they use are.

   Examples of this type of terrorist group include the Animal Liberation Front, Up the IRS, and the Earth Night Action Group. Another group that the FBI is now investigating for conspiracy is the anti-abortion groups. If the FBI is able to prove that a national conspiracy exists among these perpetrators, they could be prosecuted under domestic terrorism laws.

2. **Right-Wing Terrorism**--groups that are racist, anti-black, anti-Semitic, and for the advancement of the white race.

   Examples of this type of group include Aryan Nations, the Order, and Posse Comitatus. Many of these groups are also classified as "extremist groups." Missouri has seen some activity from these groups in the past few years. According to the Southern Poverty Law Center, Missouri has 27 extremist groups operating within its borders. Although Missouri also has a state statute against paramilitary training, one of these groups is known to have such a facility. Also, several gatherings of extremist groups have taken place within the state in recent years.

3. **Left-Wing Terrorism**--groups that are Marxist-Leninist in orientation.

   Examples of this type of terrorist group include the Armed Forces of National Liberation and the Macheteros (both from Puerto Rico), the African National Ujammu, the AnSaru Allah Community, the Dar-Ul Movement, and the United Freedom Front.

International Terrorism Trends

The United States was able to enjoy eleven years straight without having an act of international terrorism take place on our soil. However, this existence soon came to an abrupt end with the bombing of the World Trade Center in 1993, and the catastrophic attacks of September 11, 2001 by international terrorists.

III. HISTORICAL STATISTICS

United States

America was thrust into a new and far-reaching War Against Terrorism with the horrific events of September 11, 2001 when terrorists killed more than 3000 people during the attacks against the World Trade Center in New York City and the Pentagon in Washington D.C. The crashing of

highjacked U.S. jetliners into the twin towers of the World Trade Center, the Pentagon, and the Pennsylvania countryside in terrorist suicide-missions demonstrated to shocked Americans the lengths of depravity these terrorist organizations possess in their quest to attack the United States. Usama Bin Laden, acting in concert with the al Qaeda terrorist network, was quickly identified as the instigator of the September 11th attacks. The subsequent criminal mailings of anthrax letters which caused death and illness, disrupted government services and the Postal Service for months, underscore the new heights terrorism has taken with the use of Weapons of Mass Destruction and bio-terrorism devises. The individuals responsible for the anthrax mailings have not yet been identified.

Until the early '90s, Americans had only witnessed terrorist attacks on foreign soil; viewing pictures of the deliberate destruction on television and in newspapers. That all changed in 1993 with the initial bombing of the World Trade Center by international terrorists. Then, in 1995, we discovered that one of our own could unleash such utter destruction on innocent lives, when the Alfred P. Murrah Federal Building in Oklahoma City was blown apart. These events were followed by the terrorist bombings of the U.S. embassies in Tanzania and Kenya in 1998 and the attack on the U.S.S. Cole in October 2000. Bin Laden, who was linked to both embassy bombings, has vowed to attack other U.S. targets in the future.

In response to the mid-90s events, the federal government began to enact legislation and develop plans and procedures that would enable us to counteract future terrorist threats. Needless to say, these efforts increased dramatically following the events of September 11th. Among the many measures, President Bush appointed Tennessee Governor Tom Ridge to head the National Office of Homeland Security and instituted sweeping changes to improve security and intelligence gathering measures to help thwart future terrorist attacks. In March 2002, Gov. Ridge announced a national Advisory System designed to provide an effective means to disseminate information regarding the risk of terrorist attacks to Federal, State, and local authorities and to the American people. The system is organized to provide warnings in the form of a graduated "Threat Conditions (low to severe) that would increase as the risk of the threat increases.

Prior to the September 11th attacks, one suspected terrorist incident involved the derailment of the Amtrak Sunset Limited passenger train near Hyder, Arizona. One person was killed and 83 others were injured in this incident. The train track had been sabotaged, causing the train to jump the tracks and topple 30 feet from a bridge. A letter signed by the Sons of Gestapo was left at the scene. No arrests have been made in the case.

The first of the two prevented terrorist incidents occurred in March. Four members of the Minnesota Patriots Council were convicted of conspiracy to produce and possess ricin, one of the deadliest known toxins. This chemical was to be used to kill law enforcement officers and Internal Revenue Service agents.

The other prevented act of terrorism involved the Tri-States Militia (a group composed of militia from at least 30 states). Members of this group were arrested after being linked to five would-be terrorists whose bomb plots were thwarted by federal and state law enforcement agencies. The plots involved blowing-up the Southern Poverty Law Center, offices of the Anti-Defamation League, federal buildings, abortion clinics, and gay community locations.

More recently, the Olympic Park bombing in Atlanta and the downing of TWA Flight 800, both of which occurred in July 1996, are two incidents yet to be determined if terrorism was involved.

Missouri

In the wake of the September 11, 2001 attacks, Missouri Gov. Bob Holden appointed Col. Tim Daniel (USA Retired) as Special Advisor for Homeland Security, a cabinet level position, on September 26, 2001. He cooperates with state departments, including the Department of Public Safety (which includes the State Emergency Management Agency, National Guard and State Highway Patrol), as well as the Departments of Health and Senior Services, Agriculture, Transportation, Natural Resources, Social Services, Conservation, and Mental Health. In November 2001, Holden created the Missouri Security Panel to assess homeland security needs within the state. The panel oversaw a statewide vulnerability assessment, which is the basis for establishing priorities and for the allocation of resources.

Nationally, the mailing of anthrax letters in latter 2001, while claiming only several lives, caused a major disruption of government services, including the closure of the Hart Senate Office Building in Washington D.C., along with many U.S. Postal Service installations and other facilities. During this tense time in Missouri, the Department of Health and Senior Services (DHSS) issued numerous Health Alert Advisories to local officials and the public, providing guidance on how to handle anthrax or other suspicious letters/packages during a time of extremely heightened tensions. DHSS also instituted a surveillance system, contacting health providers to obtain public health information twice weekly, while also working to improve the public health infrastructure, information sharing, health communication networks, and hospital surge capabilities. A summary of Missouri's other key activities in counter-terrorism preparedness include:

- Security at the State Capitol and selected state office buildings was increased with the introduction of access control and identification cards for all state employees.

- Members of the U.S. Attorneys General Working Groups and FBI led Counter-Terrorism Task Forces in Kansas City and St. Louis.

- Missouri has worked with federal agencies to contact and provide security training to thousands of hazardous material vendors and transporters. The State Highway Patrol has increased surveillance of hazardous material transports on the highways and established a statewide intelligence and information sharing database - the Missouri State Police Intelligence Network (MOSPIN).

- The Missouri General Assembly passed legislation to improve the ability of police to detect and prevent terrorism and for authorities to respond to medical emergencies both natural and manmade.

- St. Louis University's Center for Bio-terrorism and Emerging Infections produced educational tools to help health care providers detect bio-terrorism nationwide.

IV. MEASURE OF PROBABILITY AND SEVERITY

Probability

Although this state has identified several different extremist groups operating here, there have been no indications of any specific terrorist activities. The potential does remain for some new extremist and/or terrorist group to move into the state.

An open society such as ours, which is dependent upon technology for its continued smooth operation, remains a potential target for terrorists. Large cities with a variety of news media outlets would be the most likely locations for terrorist acts. Some terrorists want their acts to reverberate in the news media and reach the largest audience possible. Since Missouri does not have large media markets when compared to the larger metropolitan states, it is not as likely a target for terrorist activity. However, after the Oklahoma City bombing, the theory that rural America is safe from terrorists has been shattered.

With this in mind, it appears that a terrorist attack could occur in Missouri, but the probability of such an attack is low.

Severity

Should Missouri experience a terrorist attack, the severity of such an attack could range from high to low, depending on the attack. For instance, if a building was blown-up and no lives were lost, the severity of the attack would be low. However, if a terrorist group decided to contaminate a large urban area's water supply with a poisonous chemical, the severity of the attack could be very high due to the number of people directly affected from the poisoned water, as well as the damage that was done to that community's sense of well-being. An attack of this nature would easily result in mass hysteria and insecurity in the government's ability to protect its citizens.

V. IMPACT OF THE HAZARD

As stated above, terrorist acts could easily undermine the confidence that people have in their own security and that of their government's ability to protect them from harm. For example, the ability to make bombs is accessible to a potential terrorist since instructions can be obtained from many sources, such as the Internet, and the materials are readily available. Since bombs can be made so easily, the threat of a bomb is not taken lightly. Even the threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the person(s) making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

VI. SYNOPSIS

There are many ways a terrorist can attack a society. Therefore, it is of upmost importance for people to be prepared as much as possible should they be threatened by or become involved in such an incident. The following guidelines from the Federal Emergency Management Agency should be used:

Before

Learn about the Nature of Terrorism:

- Terrorists often choose targets that offer little danger to themselves and areas with relatively easy public access.

- Foreign terrorists look for visible targets where they can avoid detection before or after an attack, such as international airports, large cities, major international events, resorts, and high-profile landmarks.

Learn about the different types of terrorist weapons, including explosives, kidnappings, hijackings, arson, and shootings.

Prepare to deal with a terrorist incident by adapting many of the same techniques used to prepare for other crises.

- Be alert and aware of the surrounding area. The very nature of terrorism suggests that there may be little or no warning.

- Take precautions when traveling. Be aware of conspicuous or unusual behavior. Do not accept packages from strangers. Do not leave luggage unattended.

- Learn where emergency exits are located. Think ahead about how to evacuate a building, subway, or congested public area in a hurry. Learn where staircases are located.

- Notice your immediate surroundings. Be aware of heavy or breakable objects that could move, fall, or break in an explosion.

Preparing for a Building Explosion:

The use of explosives by terrorists can result in collapsed buildings and fires. People who live or work in a multi-level building can do the following:

- Review emergency evacuation procedures. Know where fire exits are located.

- Keep fire extinguishers in working order. Know where they are located and how to use them. Learn first aid. (Contact the local chapter of the American Red Cross for additional information.)

- Keep these items in a designated place on each floor of the building--1) portable battery-powered radio and extra batteries, 2) several flashlights and extra batteries, 3) first aid kit and manual, 4) several hard hats, and 5)fluorescent tape to rope-off dangerous areas.

Bomb Threats:

If you receive a bomb threat, get as much information from the caller as possible. Keep the caller on the line and record everything that is said. Notify the police and the building management.

After you have been notified of a bomb threat, do not touch any suspicious packages. Clear the area around the suspicious package and notify the police immediately. When evacuating a building, avoid standing in front of windows and other potentially hazardous areas. Do not block sidewalks or streets that will be used by emergency officials.

During

In a building explosion, get out of the building as quickly and calmly as possible.

If items are falling off of bookshelves or from the ceiling, get under a sturdy table or desk.

If there is a fire:

- Stay low to the floor and exit the building as quickly as possible.
- Cover nose and mouth with a wet cloth.
- When approaching a closed door, use the palm of your hand and forearm to feel the lower, middle, and upper parts of the door. If it is not hot, brace yourself against the door and open it slowly. If hot, don't open the door--seek an alternate escape route.
- Heavy smoke and poisonous gases collect first along the ceiling. Stay below the smoke at all times.

After

If you are trapped in debris:

- Use a flashlight.
- Stay in your area so that you do not kick-up dust. Cover your mouth with a handkerchief or clothing.
- Tap on a pipe or wall so that rescuers can hear where you are. Use a whistle if one is available. Shout only as a last resort--shouting can cause a person to inhale dangerous amounts of dust.

Assisting victims:

- Untrained persons should not attempt to rescue people who are inside a collapsed building. Wait for emergency personnel to arrive.

Safety Alert-Secondary Explosive Devices:

These has been a recent increase in the use of flashlights as housings for explosive devices in the United States and its territories, according to the HQ Naval Criminal Investigative Service in Washington, D.C. Essentially, individuals have booby-trapped flashlights and left them at the crime scenes, bomb and arson scenes or where their intended victim will find them. To date, these devices have killed one law enforcement officer, injured several and injured a number of civilians.

The flashlights are generally metal, like the Mag-lite or Kell-lite. The batteries are removed and a small pipe bomb is inserted into the housing. The bomber then rigs the flashlight in one of two ways, either wiring the flashlight to explode when the switch is activated or setting the bomb to trigger if it is moved, by use of a purchased or improvised mercury switch. A Mag-lite rigged with an improvised motion switch claimed the life of a Puerto Rican Peace Officer.

While conducting a crime scene search, or in any circumstance when a flashlight is encountered where it is not expected, leave the light alone. If the owner is located, allow the owner to take custody of the light. If no owner can be found contact the local bomb squad. Do not attempt to open or examine the light yourself.

Chemical and Biological Agents

Chemical Agents:

- Chemical agents are poisonous gases, liquids, or solids that have toxic effects on people, animals, and plants. Most chemical agents cause serious injuries or death.
- The severity of injury depends on the type and amount of the chemical agent used and the duration of exposure.
- Should a chemical agent attack occur, authorities would instruct citizens to either seek shelter where they are and seal the premises or evacuate immediately. Exposure to chemical agents can be fatal. Leaving the shelter to rescue or assist victims can be a deadly decision. There is no assistance that an untrained person can offer that would likely be of any value to the victims of chemical agents.

Biological Agents:

- Biological agents are organisms or toxins that have illness-producing effects on people, animals, and plants.
- Since biological agents cannot necessarily be detected and may take time to grow and cause a disease, it is almost impossible to know that such an attack has occurred. If government officials become aware of a biological attack through an informant or a warning by a terrorist, they would most likely instruct citizens to seek shelter immediately where they are and seal the premises, or evacuate.

- A person affected by a biological agent requires the immediate attention of professional medical personnel. Some agents are contagious and victims may need to be quarantined. Also, some medical facilities may not receive victims for fear of contaminating the hospital population.

Dirty Bomb Action Plan Considerations:

The new terrorism worries are radiological encapsulated explosion commonly referred to as "dirty bombs." The following points need to be considered in developing a response plan.

- Secure the area in and around the explosion as you would any bomb site

- This is crime scene. Be aware terrorists might plant a secondary device to explode after first responders arrive. Incident command should be located upwind.

- Life safety measures should be paramount. Assist the injured and removed them to a safe area. The amount of radiation you could encounter in this form of attack would not be an immediate life risk to either the rescuer or the victim.

- Anyone entering the immediate explosion area and downwind area should wear protective clothing. At a minimum, tyvek suits, rubber gloves (double sets), rubber boots – standard gear for radiological monitoring. A particulate mask would be helpful but not mandatory.

- Victims needing immediate hospitalization should be evacuated from the area using standard radiological protocols where available. Cocoon the patient, remove the outer clothing and bag it for disposal. By removing the outer clothing, you will remove most of the radiological materials. Please note: cocooning the patient is wrapping the patient in blankets so that contamination will not spread.

- Use a hot zone /cold zone to transport patients from a hot zone to an uncontaminated area. Scan patients leaving the hot zone with a radiological survey instrument. Make sure anything you use in the hot zone stays in the hot zone.

- Do not try to remove/recover bodies without a coroner/medical examiner available, unless it is to get a living person to medical attention. Remember this is a crime scene and crucial evidence may be lodged in the bodies.

- Animals coming out of the contaminated area should be impounded as they may be contaminated and will have to be decontaminated prior to release to their owners (or to the wild).

! Responding departments should monitor the area in a manner similar to hazardous materials spills and prevent where possible, streams and other liquids from flowing into critical areas.

Considerations for the area downwind from the explosion:

! Radiological monitors (using CDV-700s or equivalent equipment) should plot out the deposition curves of the radiological fallout. If you don't have trained radiological monitors please contact SEMA or the Department of Health and Senior Services. These agencies have trained monitors for assistance or technical advice.

! Isolate the area that is determined to have radiological fallout form the bomb. The radiological monitors should set up perimeter controls to the area.

! After consulting with health physicists concerning the zone of contamination and whether to shelter in place or evacuate, citizens should be advised of decision and appropriate safety actions.

! Stress the response team needs to stress to the public to remain calm in order to minimize loss of life from things other than the direct effects of the explosion.

! The public needs to be reassured they will be allowed to return to the area. It may take a while to decontaminate the area, but eventually they will be allowed to return once radiological levels are brought below levels stipulated as safe by the Environmental Protection Agency (EPA).

VII. MAPS OR OTHER ATTACHMENTS

None.

ANNEX O

ATTACK
(CHEMICAL, BIOLOGICAL, RADIOLOGICAL, NUCLEAR, AND EXPLOSIVE)

I. TYPE OF HAZARD

Attack (Nuclear, Conventional, Chemical, and Biological)

II. DESCRIPTION OF HAZARD

Of all the possible disasters and hazards we can imagine, a strategic nuclear, biological, or chemical attack could be the most devastating and far-reaching in consequences. The use of these weapons against the United States in unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information.

Although the threat of all-out nuclear war has been significantly reduced with the dissolution of the Soviet Union, several scenarios still exist that might subject a jurisdiction to widespread radioactive contamination or high-level radiation exposure. Government officials and other decision makers must remember that the terms of the START II Treaty (passed by the U.S. Senate in 1996), when fully complied with at the end of 10 years from its signing, allows its signatories, Russia and the United States, to maintain 1,000 nuclear weapons each. Also, no one can deny the instability of the Korean peninsula, where nuclear weapons have been developed. Additionally, the Department of Defense estimates that as many as 26 nations may possess chemical agents or weapons, and an additional 12 may be seeking to develop them. The Central Intelligence Agency reports that at least 10 countries are believed to be conducting research on biological agents for weaponization.

While the threat of nuclear attack has diminished over the past several years, concerns over the use of chemical and biological warfare agents have increased. Recent events, such as the September 11, 2001, terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington D.C., along with followup anthrax-related attacks in 2001, have increased awareness of the vulnerability of the U.S. to future attacks involving chemical or biological warfare agents. For more information on terrorist-related issues, see the Terrorism annex (Annex N) of this document.

III. HISTORICAL STATISTICS

During World War I (1915-1918), chemical and conventional weapons were used. The first poison gas, chlorine, was used by the Germans against Allied troops in 1915. The effects of the gas were devastating, causing severe choking attacks within seconds of exposure. The British subsequently retaliated with chlorine attacks of their own, although reportedly more British suffered than the German troops, because the gas blew back into their own trenches. Phosgene was later used in the war because it caused less severe coughing, resulting in more of the agent being inhaled. Then, in September 1917, mustard gas was used in artillery shells by the Germans against the Russians. Mustard gas caused serious blisters, both internally and externally, several hours after exposure. In all, there were 1,240,853 gas-related casualties and 91,198 deaths from gas exposure during World War I.

During World War II (1941-1945), atomic (nuclear), chemical, and conventional weapons were used. Use of chemical weapons in World War II was not as prevalent as in World War I, and was primarily limited to the Japanese Imperial Army. During the war, the Japanese used various chemical-filled munitions, including artillery shells, aerial bombs, grenades, and mortars, against Chinese military forces and civilians. Chemical agents used included phosgene, mustard, lewisite, hydrogen cyanide, and diphenyl cyanarsine. The war was brought to an abrupt end in 1945, when the U.S. dropped two atomic bombs on Japan: one on Hiroshima that obliterated the entire city and killed approximately 66,000 people, and another on Nagasaki that destroyed about half the city and killed about 39,000 people.

During the Vietnam War (1964-1973), chemical and conventional weapons were used. Chemical weapons used during the Vietnam War are believed to have only involved tear agents used by the U.S., and possibly psychedelic agents, also by the U.S. Although not directly used as warfare agents, toxic herbicides such as Agent Orange were commonly used as defoliants by the U.S. Long-term exposure to Agent Orange, which contained the contaminant dioxin, was believed to cause illness and disease in humans.

In 1983, Iraq launched its first of 10 documented chemical attacks against Iran. The largest of these attacks was in February 1986, when mustard gas and the nerve agent tabun were used, impacting up to 10,000 Iranians. Although the exact number of chemical attacks implemented by Iraq during the war is unknown, the Iranian government estimates that more than 60,000 soldiers had been exposed to mustard gas and the nerve agents sarin and tabun by the time the war ended in 1988. Based on these data, the Iraqi chemical attacks during the Iran-Iraq war were the largest since World War I.

Although several isolated attacks involving biological agents have occurred over the last few decades, the most recent series of incidents in the U.S. that gained nationwide exposure occurred between early October and early December 2001, when five people died from anthrax infection, and at least 13 others contracted the disease in Washington, D.C.; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. Senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination. In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Fortunately, almost all of these incidents turned out to involve no actual biohazard.

IV. MEASURE OF PROBABILITY AND SEVERITY

Attacks against the United States as a whole, and against individual states or local entities, can be categorized as originating from either domestic or international sources. However, because the impacts on life and property would largely be the same regardless of the source of such an attack, similar preparedness, response, and recovery activities apply.

Biological and chemical weapons have often been used to terrorize an unprotected population, instead of actual use as weapons of war. However, the potential damage that can occur in the event of such an attack is huge, particularly to human health.

A single nuclear weapon detonation could cause massive destruction, and all aforementioned types of attacks could cause extensive casualties. An all-out nuclear attack could affect the entire population in the vicinity of the impacted area. Some areas would experience direct weapons effects: blast, heat, and

initial nuclear radiation. Other areas would experience indirect weapons effects, primarily radioactive fallout. As long as world leaders maintain rational thinking, the probability of an attack by any of the aforementioned methods remains low.

Secondary effects of these attacks, which could severely stress the country, include lack of adequate shelter, food, water, health and medical facilities and personnel, and mortuary services, disruption of communication systems, and power outages. Because of the potential devastation and significant secondary effects caused by this type of attack, the severity is rated high.

V. IMPACT OF THE HAZARD

The population is vulnerable to two separate categories of impacts associated with these types of attacks: direct and indirect impacts. For more information on these impacts, which are often connected to terrorist-related activities, see the Terrorism annex (Annex N) of this document.

A. Direct Effects

These are effects directly associated with detonation or use of the weapon.

1. Conventional Weapons

Direct effects of conventional weapons generally are related to injuries inflicted by penetration of ammunition rounds or shrapnel from exploding ordnance (mortars, etc.). Injuries from shock waves/blast overpressure near the targets may also occur, along with damage caused by fires produced from incendiary warheads, grenades, and other munitions. In addition, some injuries may occur as a result of flying or falling debris where the weapons are used. Heavy artillery use can also damage roadways and buildings, and disrupt utility services for lengthy periods of time.

2. Chemical and Biological Weapons

Direct effects of chemical weapons involve initial spread of agents and fragmentation of the weapons. Chemical agents are toxins used to produce neurological and pulmonary injuries or death. Biological agents are infectious microbes used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes for chemical agents) or a delayed effect (several hours to several days for biological agents). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.

3. Nuclear Weapons

Direct effects include intense heat, blast energy, and high-intensity nuclear radiation. These effects generally will be limited to the immediate area of the detonation (up to 22 miles), depending on weapon size, altitude of burst, and atmospheric conditions.

4. Agroterrorism

The direct effect of agroterrorism is the intentional use of a biological weapon on livestock and food crops to disrupt the food supply chain. Agroterrorism will cause disease in livestock, crops, and humans who consume food products. It will require the agriculture industry to destroy livestock and food crops.

5. Radiological Weapon

Direct effects of a radiological weapon are penetration by shrapnel by the blast, radiological poisoning from penetration of radiologically contaminated shrapnel, and ingestion of minute radiological particles. A Radiological Dispersion Device (RDD) or "dirty bomb" will contaminate an area by penetration of shrapnel into structures and settlement of dust and debris on the area.

6. Explosive Weapon (large amount of high exposive)

The direct results of an explosive weapon are immense destruction caused by the blast and multiple fatalities. Instances of these effects include Oklahoma City, Kobhar Towers, the marine barracks in Lebanon, and the African Embassy bombings.

B. Indirect Effects

These are effects not directly associated with the detonation and use of the weapon.

1. Conventional Weapons

Unexploded ordnance throughout a battle zone or explosion hazards to those in the area can persist after warfare has ended. Many conventional munitions also contain toxic compounds that can leach into surrounding soils and groundwater if left in place.

2. Chemical and Biological Weapons

Indirect effects are generally limited to downwind areas. They can be geographically widespread and vary in intensity—depending on weapon size, type of chemical or biological agent, and wind patterns. The spread of these agents can contaminate food and water supplies, destroy livestock, and ravage crops.

3. Nuclear Weapons

When a nuclear weapon explodes near or on the ground, it draws up large quantities of earth and debris into a mushroom cloud. This material becomes radioactive, and the particles can be carried by wind hundreds of miles before they drop back to earth as "fallout." In an attack, many areas of the United States would probably escape fallout altogether or experience non-life-threatening levels of radiation. However, because weather that determines where fallout will land is so unpredictable, *no* locality in the United States is free from risk of receiving deadly radiation levels after a strategic attack.

4. Agroterrorism

Agroterrorism's indirect effects are loss of breeding stock to replenish herds and flocks; loss of seed crops; and possibly loss of land use for a long period of time depending on the disease involved. Agroterrorism has a high probability of creating an economic downturn.

5. Radiological Weapon

The indirect effect of a RDD is inability to use the contaminated area for a short-to-long time period, depending on the identify of the radioactive material. Because radioactive material from a RDD can penetrate wood, asphalt, concrete, and masonry (and radioactive dust and particles can enter the smallest crevices), decontamination will be extremely difficult or impossible.

6. Explosive Weapon (large amount of high explosive)

The indirect effect of an explosive weapon is the fear, terror, and lasting psychological damage done to survivors and other individuals.

VI. SYNOPSIS

Even though the START treaty has reduced the overall number of nuclear weapons, and many chemical weapons stockpiles are scheduled to be destroyed, we must continue to plan for, and be prepared for, this type of hazard.

While it may not be possible to prevent such an attack, steps can be taken to lessen the likelihood or the potential effects of an incident by implementing certain measures:

- Identifying and organizing resources
- Conducting a risk or threat assessment and estimating losses
- Identifying mitigation measures that will reduce the effects of the hazards and developing strategies to deal with the mitigation measures in order of priority
- Implementing the measures and evaluating the results (and keeping the plan up-to-date).

VII. MAPS OR OTHER ATTACHMENTS

No attachments or maps are available.

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PUBLIC HEALTH EMERGENCIES; ENVIRONMENTAL ISSUES

I. TYPE OF HAZARD

Public Health Emergencies;
Environmental Issues

II. DESCRIPTION OF HAZARD

Public health emergencies can take many forms - disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological or biological agents, and large-scale infestations of disease-carrying insects or rodents - to name just a few. **The first part of this annex focuses on emerging public health concerns. A second annex category, Environmental Issues, covers events which pose an adverse impact to air and/or water through the release of pollutants, by natural or man-caused means.** These are noted in Section VI (Synopsis) of this annex.

Public health emergencies can occur as primary events by themselves, or they may be secondary events to another disaster or emergency, such as flood, tornado, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be statewide, regional, or localized in scope and magnitude.

In particular, two public health hazards have recently emerged as issues of great concern, with far reaching consequences. One would be the intentional release of a radiological, chemical, or biological agent, as a terrorist act of sabotage, to adversely impact a large number of people. The second hazard would be a deadly flu outbreak (influenza pandemic) that could kill or sicken thousands of people across the county or around the globe, as in the case of the Spanish Flu epidemic of 1918-19. Such a pandemic could occur either by natural means, or man-caused as a bio-chemical terrorist activity. **For more information on bio-chemical terrorism, see the Terrorism Annex in this State Hazard Analysis.**

Whether natural or man-caused, health officials say the threat of a dangerous new strain of influenza virus in pandemic proportions is a very real possibility in the years ahead. Unlike most illnesses, the flu is especially dangerous because it is spread through the air. A classic definition of influenza is a respiratory infection with fever. Each year, one or more forms of the flu infect humans and spreads around the globe. There are three types of influenza virus, known as Types A, B, and C. Type A is the most common, most severe, and the primary cause of flu epidemics. Type B cases occur sporadically and sometimes as regional or widespread epidemics. Type C cases are quite rare and hence sporadic, but localized outbreaks have occurred. Fortunately, influenza usually is treatable and the mortality rate remains low. Each year, scientists estimate which particular strain of flu is likely to spread, and they create a vaccine to combat it. A flu pandemic occurs when the virus suddenly changes or undergoes an “antigenic shift,” permitting it to attach to a person’s respiratory system and leaving the body’s immune system defenseless against the invader.

III. HISTORICAL STATISTICS

Epidemic influenza, an age-old infectious disease, kills several thousand men and women in the United States every year. Since the early 1900's, several lethal pandemics have swept the globe, although none have compared to the infamous Spanish Flu event of 1918-19, which killed more than 20 million people. The 1957 Asian Flu and the 1968 Hong Kong Flu also were killers, although they weren't nearly as virulent as the 1918 strain. The '57 epidemic killed about 70,000 people in the United States - mostly the elderly and chronically ill. Another 34,000 Americans died from the '68 epidemic. While both these epidemics cost many lives, they were not nearly as severe as the Spanish Flu of 1918, which claimed more than 700,000 lives in the U.S. alone. Its primary victims were mostly young, healthy adults.

SPANISH FLU OF 1918-19

In 1918, while World War I was in its fourth year, another threat began that would rival the war itself as the greatest killer in human history. The Spanish Flu swept the world in three waves during a two-year period, beginning in March 1918 with a relatively mild assault. The first reported case occurred at Camp Funston, (Fort Riley) Kansas, where 60,000 soldiers trained to be deployed overseas. Within four months, the virus traversed the globe, as American soldiers brought the virus to Europe. The first wave sickened thousands of people and caused many deaths (46 died at Camp Funston), but it was considered mild for what was to come. The second, deadliest wave struck in the autumn of 1918 and killed millions. At Camp Funston alone, there were 14,000 cases reported and 861 deaths during the first three weeks of October, 1918. Outbreaks caused by a new varient exploded almost simultaneously in far-flung locations, including France, Sierra Leone, Boston, and New York City, where more than 20,000 people died that fall. The flu gained its name from Spain, which was one of the hardest hit countries. From there, the flu went on through the Middle East and on around the world, eventually returning to the U.S. as American soldiers came home during its second wave. Of the 57,000 Americans who died in World War I, 43,000 died as a result of the Spanish influenza. At one point, more than 10 percent of the American workforce was bedridden. By a conservative estimate, a fifth of the human race suffered the fever and aches of influenza in 1918-19, with 20 million having died.

In 1918, Missouri's influenza death rate was 293.83 per 100,000 people - for a total of 9,677 deaths statewide from that cause alone, according to Missouri State Board of Health statistics. That figure represents18.6 per cent of Missouri's total deaths that year. While the cause of the Spanish Flu remains much a mystery, the epidemic was generally traced to pigs on Midwest farms, which then spread the deadly virus to farm families. As fall crops were ready for harvest in1918, there were no field hands to get the crops in, thereby creating an agricultural disaster as well. A third wave of the Spanish Flu, much less devastating than its predecessors, made its way through the world in early 1919 and then it finally died out

Missouri's flu death rate in1919 dropped to less than half that of the previous year (107.21 per 100,000), and by 1921, it was reduced to 87.24 deaths per 100,000 people, state statistics show.

'76 SWINE FLU AND '97 HONG KONG FLU OUTBREAKS

In addition to the 1957 Asian and 1968 Hong Kong flu epidemics, two more recent outbreaks have caused great alarm in the medical community. In 1976, a swine-type influenza virus appeared in a U.S. military barracks (Fort Dix, New Jersey). Scientists determined it was an "antigenically drifted variant of the feared 1918 virus. Fortunately, a pandemic never materialized, although the news media made a significant argument about the need for a swine-flu vaccine.

In March, 1997 scores of chickens in Hong Kong's rural New Territories began to die - 6,800 on three farms alone. The virus was especially virulent, and made an unusual jump from the chickens to humans. At least 18 people were infected and six died in the outbreak. Chinese authorities acted quickly to exterminate over one million chickens, and successfully prevented further spread of the disease. While the outbreak highlighted the success of the surveillance network, it also showed how dangerously mutable influenza viruses can be. In their most sinister forms, such as the 1918 Spanish Flu, they can be as deadly as any disease known to man.

IV. MEASURE OF PROBABILITY AND SEVERITY

Health officials agree there is a high probability we will see another dangerous new strain of the influenza virus sometime in the future, according to the Missouri Department of Health. In fact, a world-wide influenza outbreak on the scale and severity of the Spanish Flu is not far-fetched, and, in fact, is expected by many experts. Should such a killer virus strike today, the results in Missouri and elsewhere could be catastrophic. Today, a much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus literally could be spread around the globe within hours. Under such unique conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a novel influenza strain is identified and the time that outbreaks begin to occur in the U.S. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make an influenza pandemic unlike any other public health emergency or community disaster.

V. IMPACT OF THE HAZARD

For planning purposes, it would be reasonable to assume a rapid movement of a pandemic flu virus from major metropolitan areas to rural areas of the state. The effect of a pandemic on individual communities will be relatively prolonged - weeks to months. The impact of the next pandemic could have a devastating effect on the health and well being of Missouri citizens and the American public. CDC estimates that in the U.S. alone:

* Up to 200 million persons will be infected.

* Between 40 and 100 million persons will become clinically ill.

* Between 18 and 45 million persons will require outpatient care.

* Between 300,000 and 800,000 persons will be hospitalized.

* Between 88,000 and 300,000 people will die nationwide.

* Effective preventive and therapeutic measures – including vaccines and antiviral agents – will likely be in short supply, as well as some antibiotics to treat secondary infections.

* Based on the CDC's preliminary estimates, economic losses from the next pandemic may range from $71 to $166 billion, depending on the attack rate.

VI. SYNOPSIS

How would businesses and government services operate if 40 per cent of the staff called in sick as a result of a major flu epidemic? What if the flu attacked health care providers, essential public services, schools, and the private business sector at the same rate? To address these and numerous other mounting concerns, the Missouri Department of Health (MODH) and the State Emergency Management Agency (SEMA) were selected by the Center for Disease Control and Prevention (CDC) and the Council of State and Territorial Epidemiologists (CSTE) to test a national plan for dealing with such a catastrophic flu outbreak. MODH and SEMA designed an interactive exercise, "FLUEX '98" to test the national response documents - the draft Influenza Preparedness Plan for the United States, and the draft Pandemic Influenza, a Planning Guide for State and Local Officials. These documents were used for both the design of FLUEX, and during the exercise play itself. FLUEX was held Feb. 4-5, 1998 in the State Emergency Operations Center at SEMA headquarters, Jefferson City, Mo., and included more than 100 participants. Missouri was the only state in the nation to hold such an exercise, and one of only six states to help test the proposed national plan. Major topics explored during FLUEX included:

* identifying quickly circulating viruses

* allocating possibly scarce vaccine supplies

* communicating emergency health information to the public, and

* keeping essential public safety services operating during a time of widespread illness among employees

As a follow-up to that planning event, the Federal Emergency Management Agency (FEMA) conducted a satellite video conference on planning for a pandemic influenza, which was broadcast nationally on February 25, 1999. SEMA, the Missouri Department of Health, and local health

departments hosted sites for the telecast across the state. The video-conference highlighted Missouri's planning efforts to date and also featured health officials from Connecticut and Maine. They joined with a special panel at CDC headquarters in Atlanta, including SEMA's exercise officer, to answer a wide range of call-in questions on crisis management for a pandemic.

Missouri's recommendations for changes to the National Pandemic Influenza Planning Guide were submitted by the FLUEX '98 design team in April 1998 to the CDC and the CSTE. In addition to specific feedback about each section of the Guide, several general observations emerged during Missouri's two-day FLUEX '98. These were in the areas of: vaccine distribution; trigger(s) for the emergency response system; generic measures to prevent transmission; and target dates for implementation of state and local responsibilities. Other states participating in the plan review shared many of Missouri's same concerns.

Preparations and design for the pilot FLUEX exercise was a major undertaking, jointly coordinated by SEMA and the Missouri Department of Health (MDOH). An 18-member planning committee representing 14 agencies held weekly or biweekly meetings between early October 1997 and the exercise dates of February 4-5, 1998. Agencies represented were: MDOH Office of Epidemiology, MDOH State Health Laboratory, MDOH Center for Local Public Health Services, MDOH Emergency Response, MDOH Bureau of Immunizations, MDOH Office of Surveillance, SEMA, Dept. of Corrections, Mo. Dept. of Elementary and Secondary Education, MO. Dept. of Social Services (Division of Aging), Mo. National Guard, Mo. Army National Guard, and Statewide Volunteer Organization.

Participants for FLUEX '98 were invited from a wide range of federal, state and local agencies and departments. They included CDC; FEMA; U.S. Public Health Service; Emergency Medical Preparedness Office, Dept. of Veterans Affairs; Office of Emergency Preparedness, Dept. of Health and Human Services: Mo. Pharmacy Assn.; Mo. Dept. of Elementary and Secondary Education; State Schools for Severely Handicapped; Red Cross; Salvation Army; and private, state and veterans's hospitals. Others were: managed care groups; Mo. Hospital Assn.; Mo. State Medical Assn.; Mo. Emergency Medical Assn.; State Office of Administration, Risk Management; law enforcement; fire safety and prevention; correctional facilities; and Mo. Air and Army National Guard.

The sudden and unpredictable emergence of pandemic influenza and its potential for causing severe health, social, and economic consequences strongly require the need for a comprehensive, action-oriented strategy, health planners say. Principal goals of the national plan are two-fold: to improve prevention and control of influenza in the U.S. during the present (interpandemic) period, and to identify and implement specific ways and procedures to improve readiness for a future pandemic. As the CDC revises the draft national plan, Missouri will prepare an emergency response plan to deal with influenza pandemic on the state level, MDOH officials say. They emphasize that Missouri needs to prepare now to deal with challenges that could arise, such as vaccine shortages, widespread illness, and disruption in essential services.

Environmental Issues

Although the state has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July '93, for example, St. Joseph City's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt waste water treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and smog problems from air pollutants existing in large metropolitan areas.

Air Pollution: Air quality in Missouri is monitored by 139 stations throughout the state. These stations are maintained by the U.S. Environmental Protection Agency (EPA), and state and local authorities. These stations can be divided into three separate groups: the National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and Special Purpose Monitors (SPM). These monitors measure suspended particulate, ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and lead. The last item listed is a unique one. Missouri's lead industry produces about 90% of the new lead in the nation. The three large lead smelters in Missouri (near Herculaneum) have their own monitoring network operated by the company that runs the smelters. It should be noted that the State monitors the network to ensure proper function. All data is forwarded to EPA. The EPA maintains a list of facilities which release the most toxic chemicals per year. Missouri's list of five top facilities for1997 is shown in Figure1 in Section VII of this annex. The top ten chemicals for total releases in the state is shown in figure 2.

Because of high amounts of ozone, carbon dioxide, and other vehicular pollutants in the St. Louis Metropolitan Area, vehicles registered in the counties of St. Louis, St. Charles and Jefferson, as well as St. Louis City, are required to have an emissions check of their exhaust systems. All service areas around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more information on the Air Pollution Control Program, contact the Missouri Department of Natural Resources at (573) 751-4817.

Water Pollution: The Missouri Department of Natural Resources also maintains the state's water quality management plan, and has individual plans for each drainage basin in Missouri. These are: Grand/Chariton Rivers Basin, Des Moines/Salt Rivers Basin, Osage/Gasconade River Basin, Meramec and small direct tributaries to the Mississippi Basin, and Missouri and small direct tributaries.

In all, 20,536 miles of Missouri waterway come under the provisions of the state's Clean Water Act. Of these waters, 50.6 percent (10,390.5 miles) meet clean water goals. The remaining 10,145.5 miles of water do not meet the clean water goals, but only 70.5 miles are considered serious

water quality problems. Of the 10,145.5 miles of waterway not meeting the goals, it is estimated that 5,000 to 8,000 miles will probably never meet the goal of good aquatic habitat (fishable) because of natural conditions.

Types of Water Pollutants: The most recent available water quality report indicates the most important pollutants in Missouri are:

- Sediment deposited in streams from soil erosion.
- Acid mine drainage from abandoned coal mines (acidity, sulfate, iron, and coal solids).
- Municipal sewage treatment plant effluent (ammonia, fecal coliform, and suspended solids).
- Depositions of lead/zinc mine tailings (silt-sized mineral particles).
- Releases from reservoirs (low dissolved oxygen, manganese, temperature changes, velocities).

The water quality report also states there are several other water quality concerns:

- Stream channelization, which causes degradation and even loss of aquatic habitat, increases in erosion/severity of flooding, increases of water temperature and reduction of oxygen level.
- Abandoned lead-zinc mining areas allow streams to increase sediments deposited and allow heavy metals to enter the food chain through dissolution.
- High-density residential and commercial development in areas around the Lake of the Ozarks has made it impractical to have centralized sewage collection and treatment.
- Hazardous waste sites in Missouri deposit a plethora of chemicals into Missouri waterways. Until these sites are cleaned up, they will continue to be hazardous to people and wildlife.

Identifying Pollution Hazard Areas

Local emergency management officials should identify pollution hazard areas so that in case of a natural disaster, recovery steps will not be delayed. Pollution of public drinking water, for example, can cause severe problems with re-entry and recovery. If alternate sources of safe drinking water can be identified, or relocation of water intakes can eliminate polluted drinking water, then recovery can be that much quicker and local resources can be used to tackle other problems.

With the increases in motor vehicle registrations throughout the state, the levels of nitrocarbon emissions will naturally rise. Combinations of smog and carbon monoxide levels will also increase. These elements in sufficient quantities can have deleterious effects on the health of thousands of Missourians.

VII. MAPS AND OTHER ATTACHMENTS

Attachments to this annex include EPA's Top Five List of Facilities in Missouri Releasing Toxic Chemicals (Table 1); and EPA's List of Top Ten Chemicals in Missouri for Total Releases (Table 2).

Table 1:

EPA List of Top Five Facilities That Release Toxic Chemicals In Missouri (1997)
(All figures are in pounds)

FACILITY	COUNTY	AIR	WATER	LAND	TOTAL
Asarco, Inc.	Iron	63,262	24	10,787,952	10,851,238
Doe Run Co.	Jefferson	262,535	405	8,466,990	8,729,930
Royal Oak Ent. Inc.	Carter	3,255,696	0	0	3,255,696
Craig Ind.	Shannon	2,722,752	0	0	2,722,752
Ford Motor Company	Clay	2,456,496	0	0	2,456,496

Note: Missouri had no releases in 1997 through underground injection.

Table 2:

EPA List of Top Ten Chemicals In Missouri For Total Releases in 1997
(All figures are in pounds)

CHEMICAL	AIR	WATER	LAND	TOTAL*
Methanol	10,012,705	8,077	5	10,020,787
Zinc Compounds	184,450	553	7,431,340	7,616,343
Zinc (fumes or dust)	15,297	7	6,795,600	6,810,904
Xylene (mixed isomers)	4,362,721	0	0	4,362,721
Lead	48,144	336	3,443,195	3,491,675
Nitrate Compounds	736	2,680,722	755	2,682,213
Toluene	1,994,611	48	911	1,995,570
N-Hexane	1,907,744	0	0	1,907,774
Certain Glycol Ethers	1,828,298	5	6,799	1,835,102
Methyl Ethyl Ketone	1,834,323	110	0	1,834,433

* Total amounts do not include off-site transfers.

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Statistics: Influenza death rates, 1918-1921, Missouri State Board of Health; FLUEX '98, State Emergency Management Agency and Missouri Department of Health; 1997 Toxics Release Inventory, Missouri Department of Natural Resources, Division of Environmental Quality, Technical Assistance Program, and U.S. Environmental Protection Agency.